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(54) DYNAMIC, MODULAR, MULTILOCK
ANTERIOR CERVICAL PLATE SYSTEM
HAVING DETACHABLY FASTENED
ASSEMBLEABLE AND MOVEABLE
SEGMENTS, INSTRUMENTATION, AND
METHOD FOR INSTALLATION THEREOF

Publication Classification

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(57) ABSTRACT

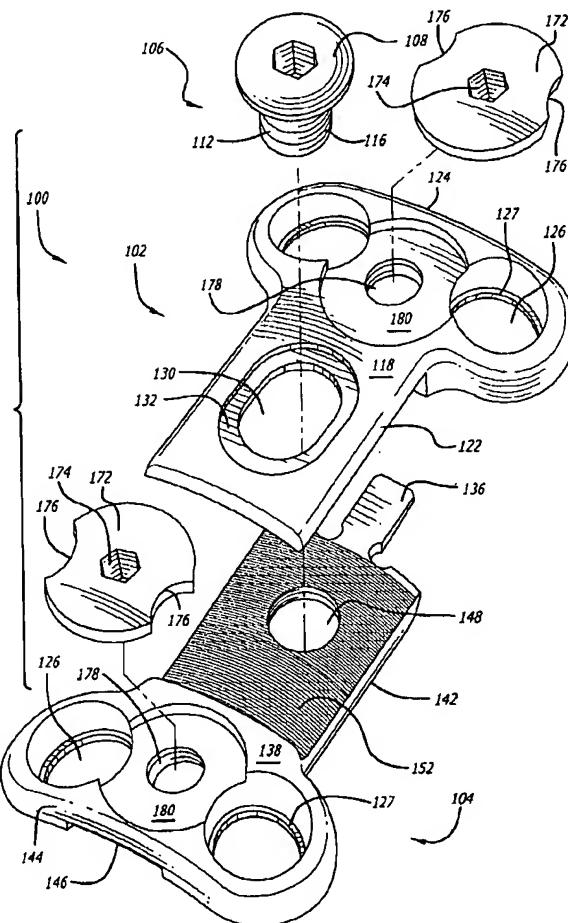
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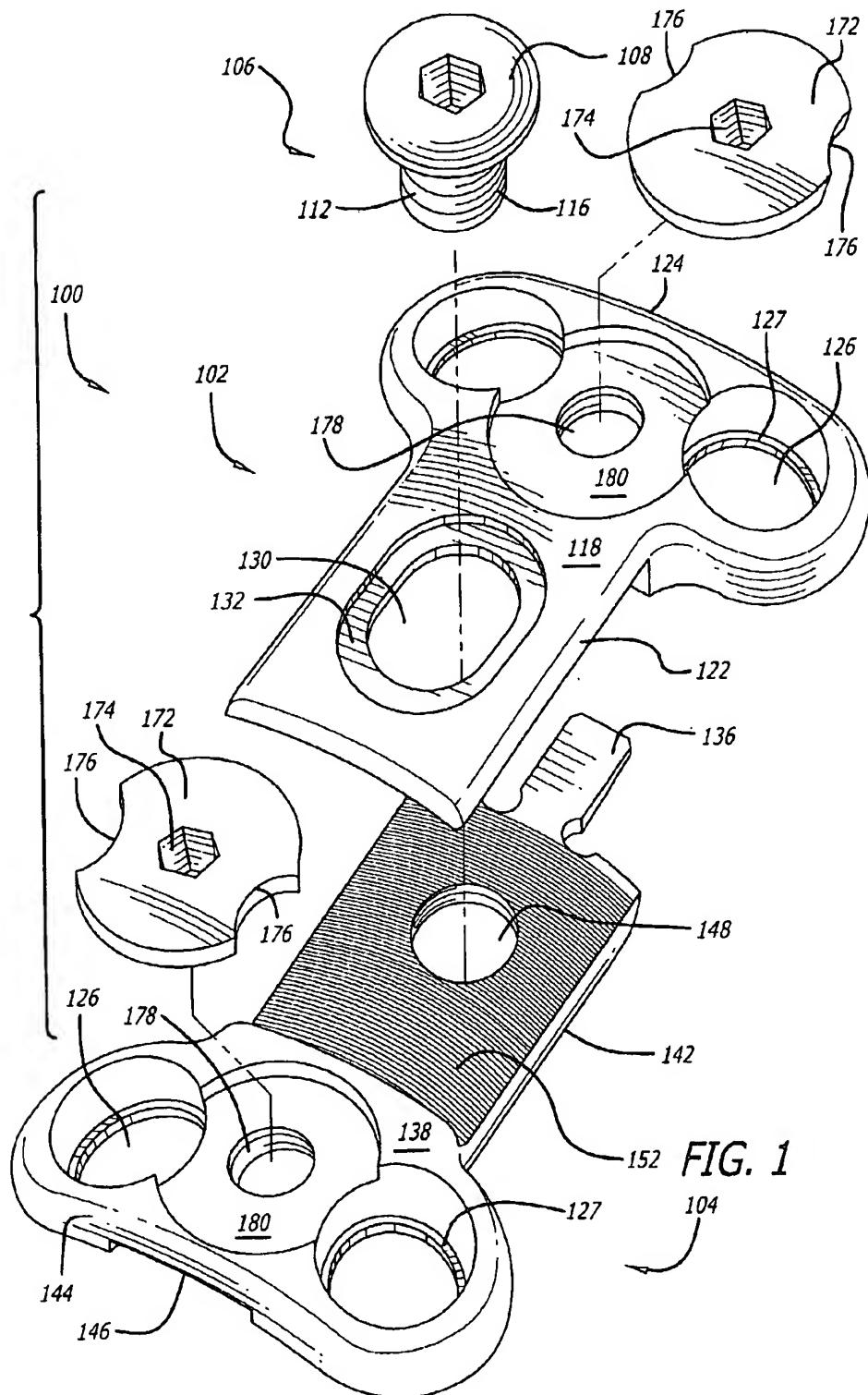
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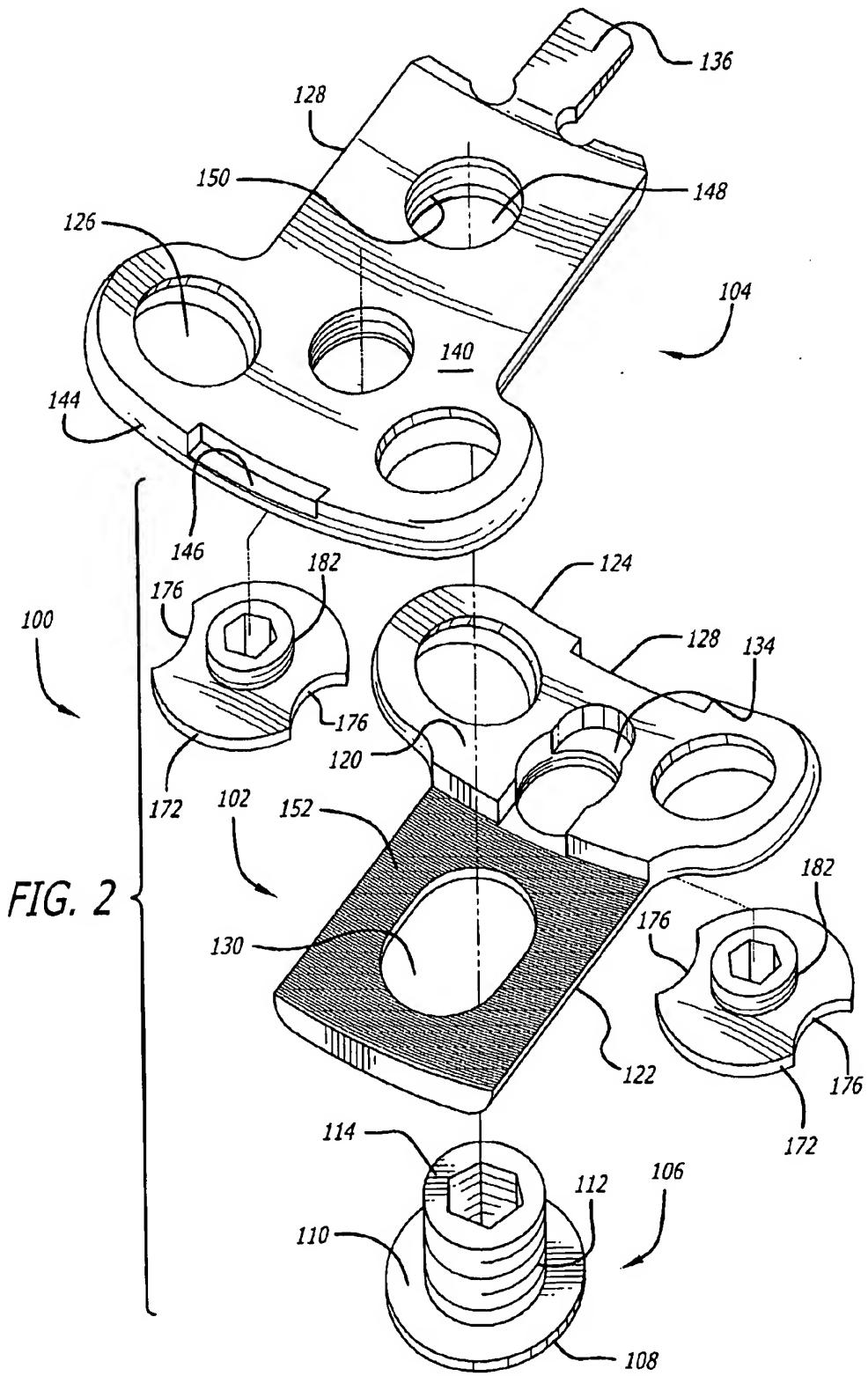
Related U.S. Application Data

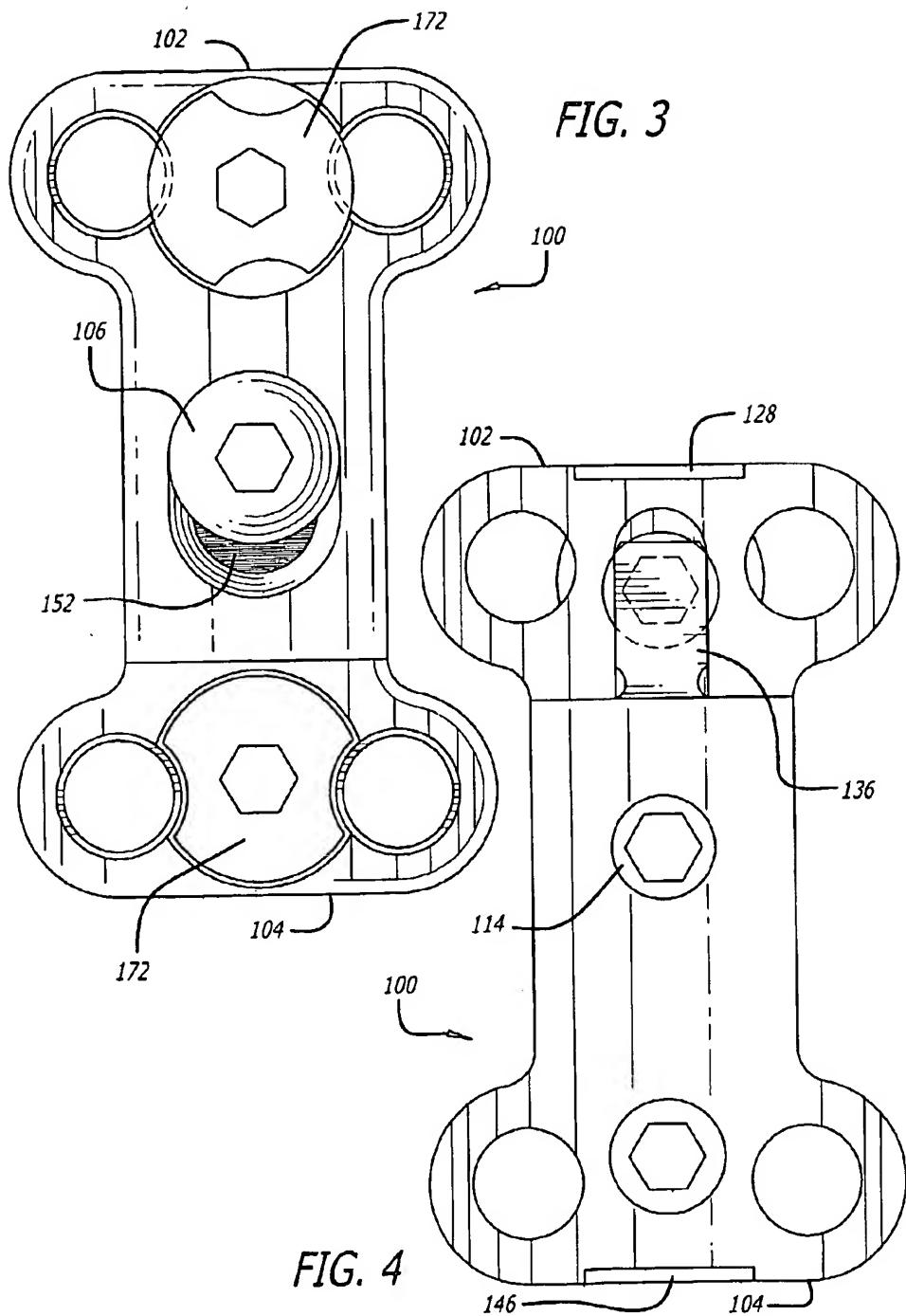
(60) Provisional application No. 60/296,680, filed on Jun. 6, 2001. Provisional application No. 60/377,916, filed on May 3, 2002.

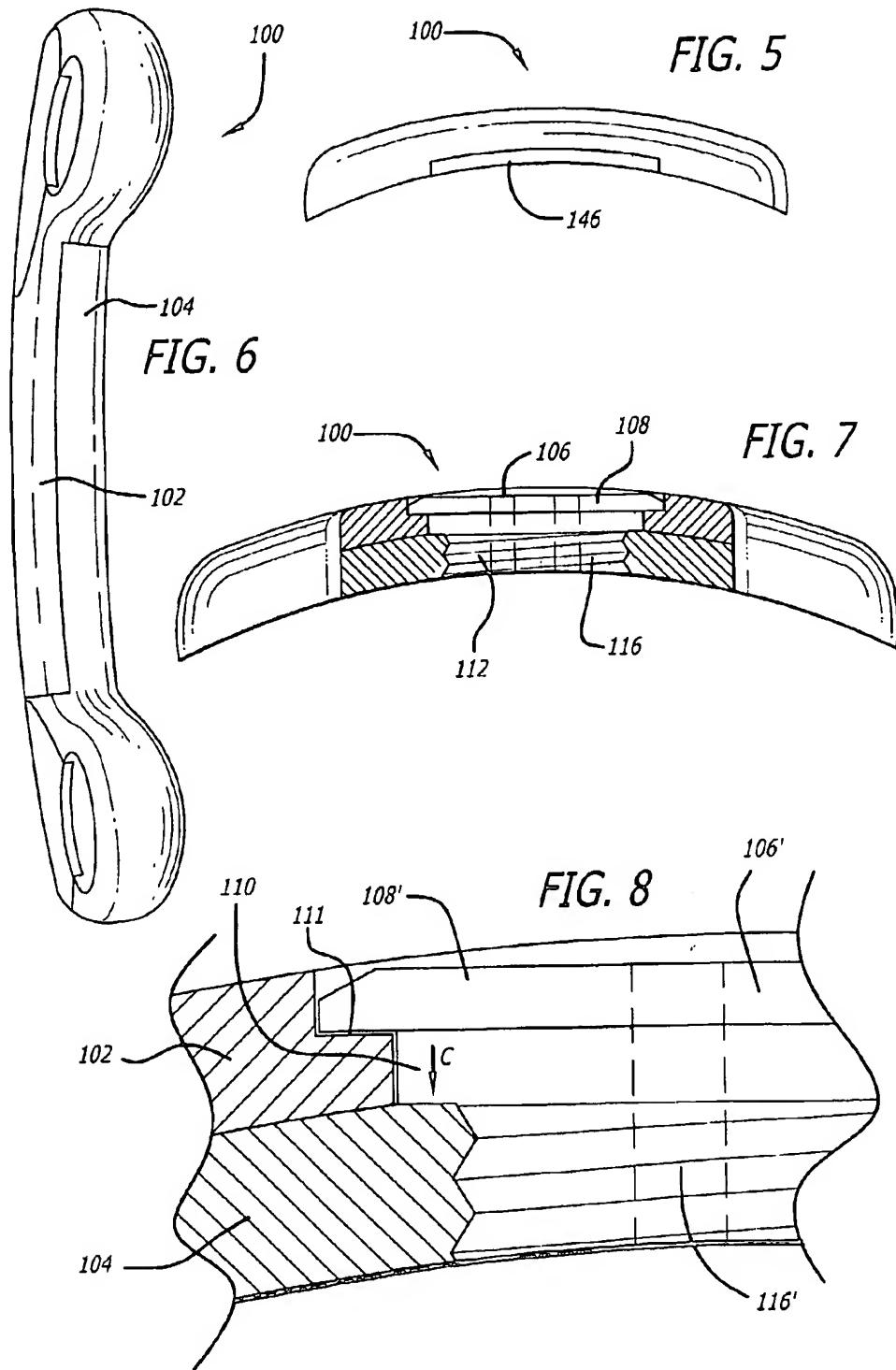
An anterior cervical plating system having moveable and modular plate segments that are assembleable to vary the overall length of the plate, moveable to allow and/or cause intersegmental compression of vertebral bodies, and coupled together by a detachable fastener. The plating system includes locking elements, each locking element adapted to lock at least two bone screws to the plate, instrumentation, and method for installation thereof. The plating system is capable of both passive and active dynamization and the ability to produce the former from the latter.











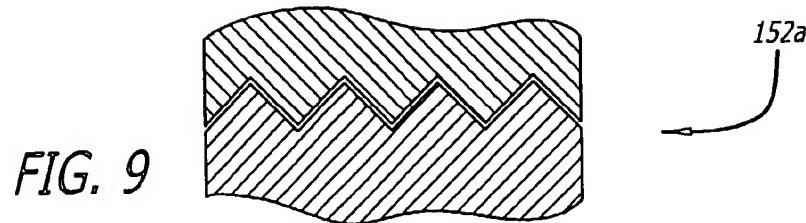


FIG. 9

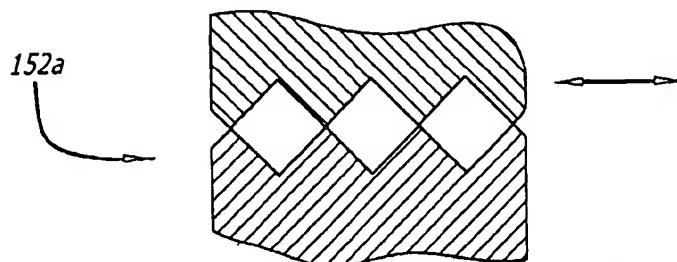


FIG. 10

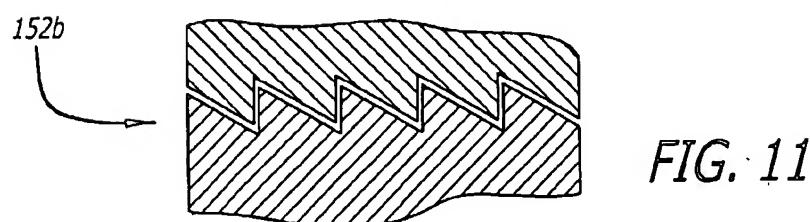


FIG. 11

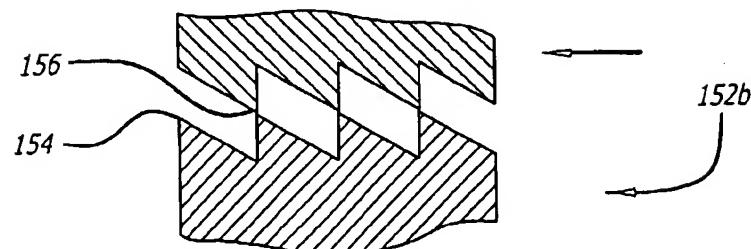
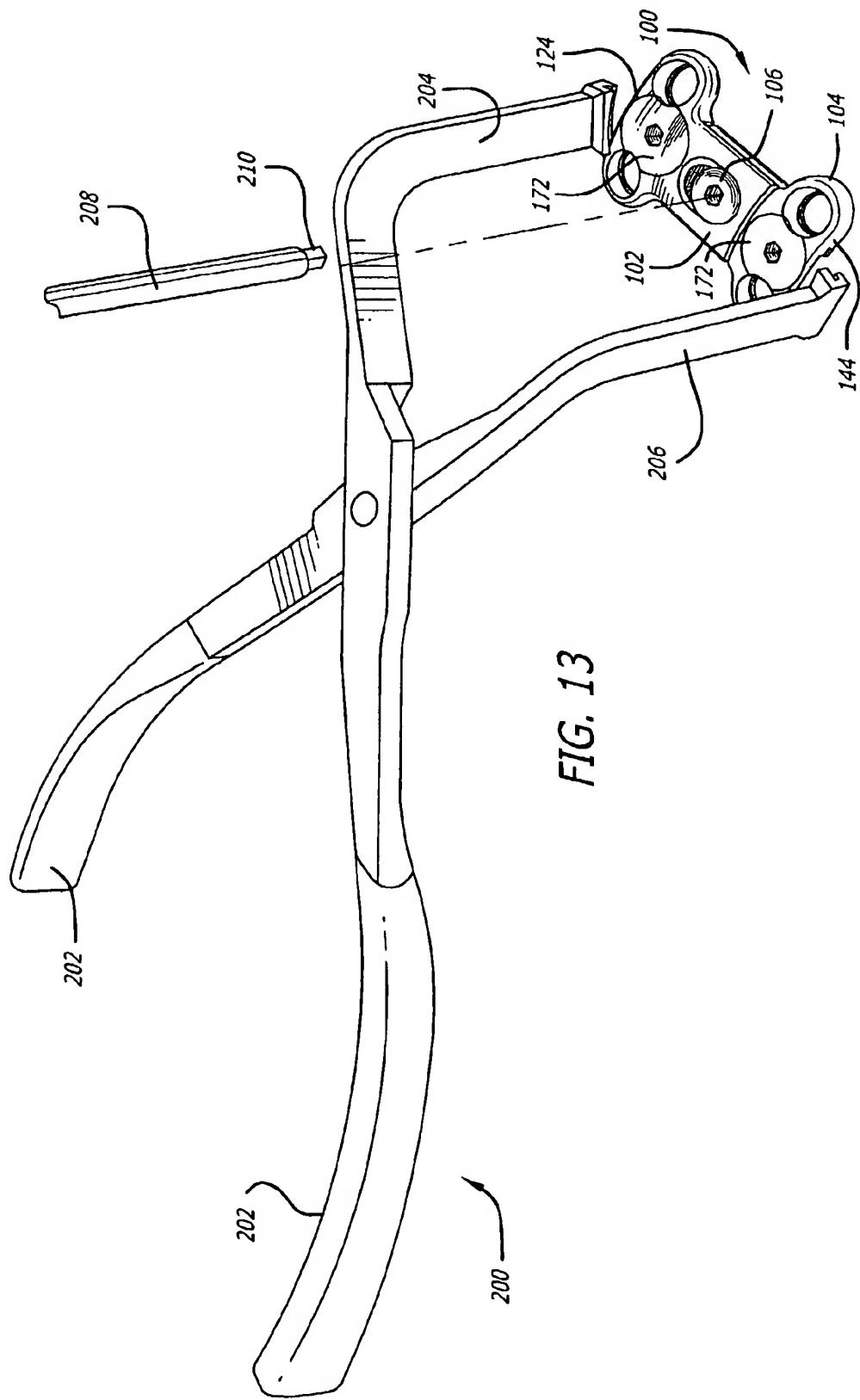


FIG. 12



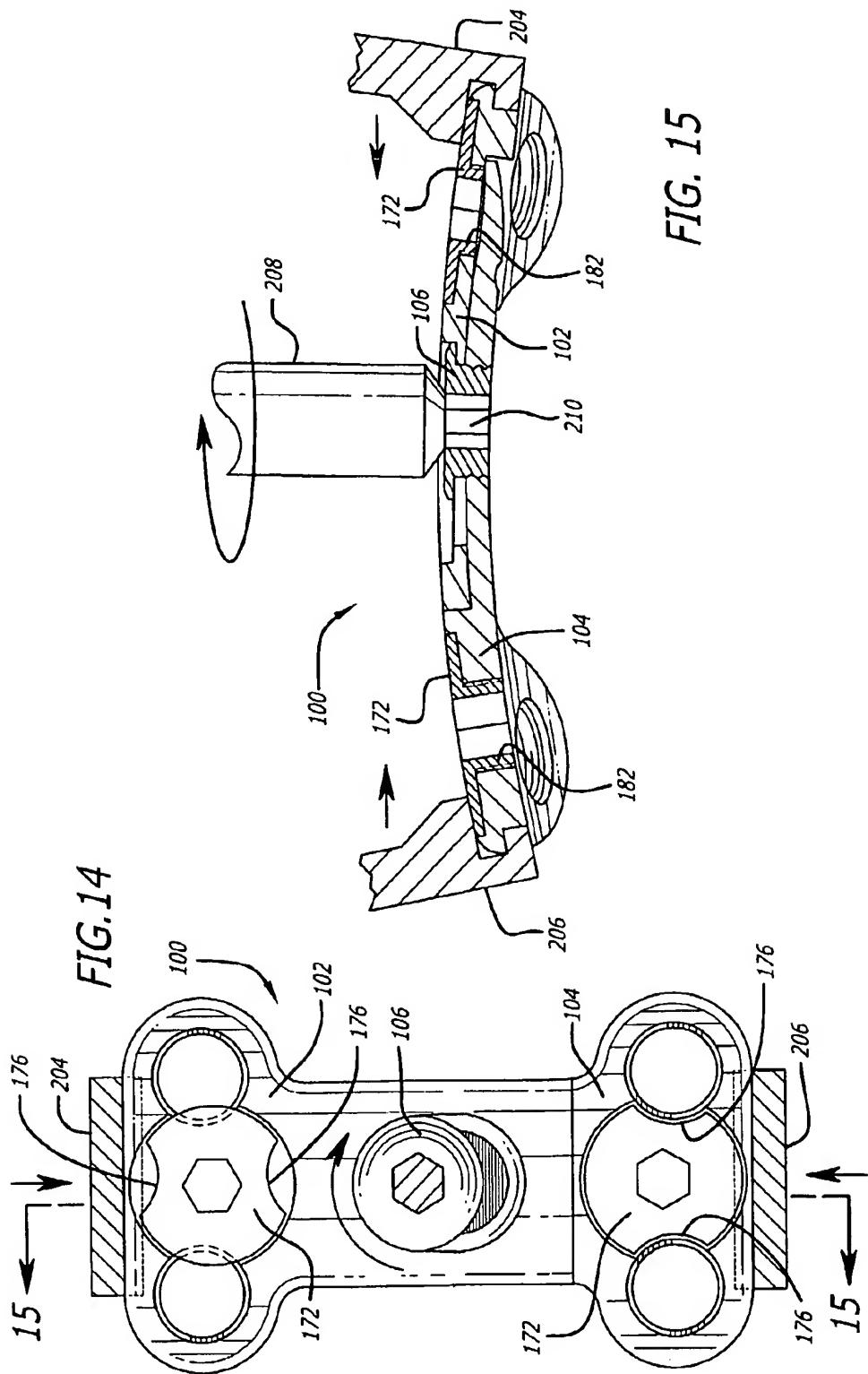
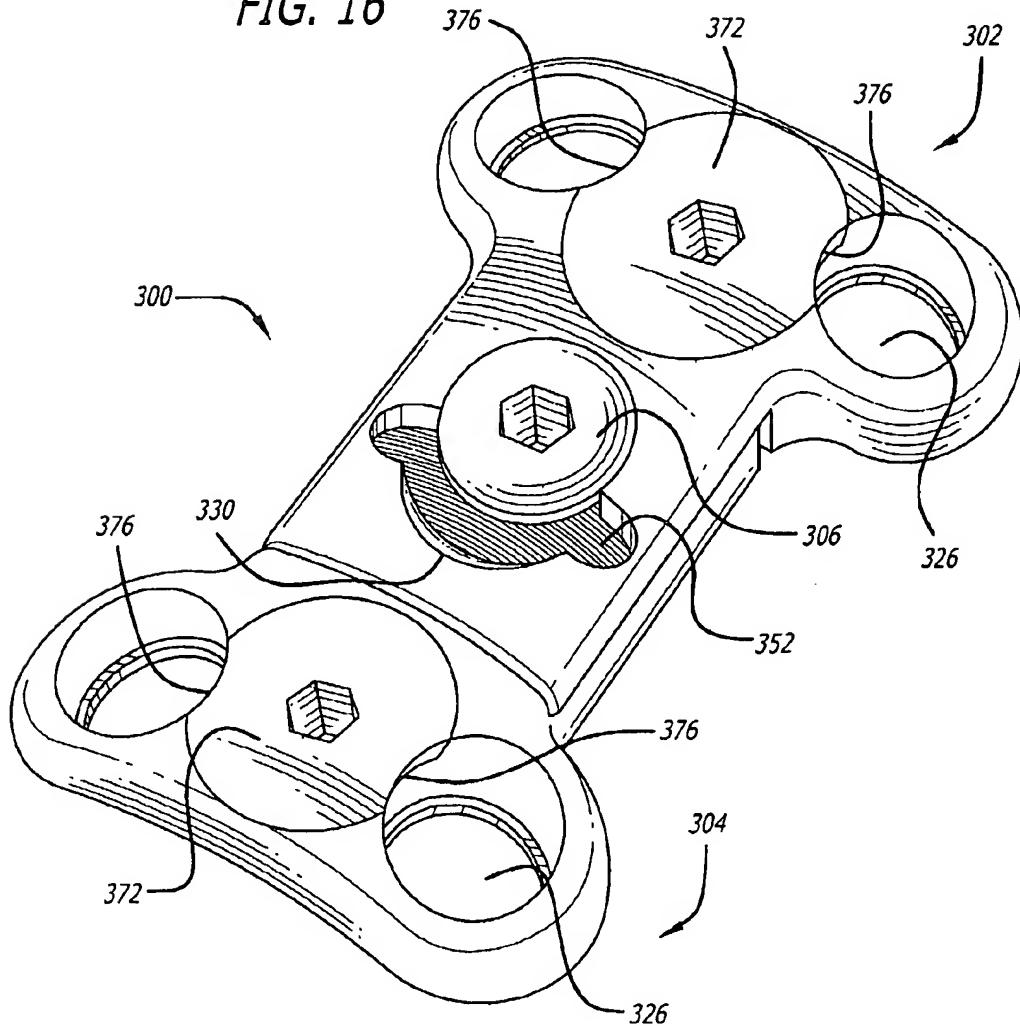
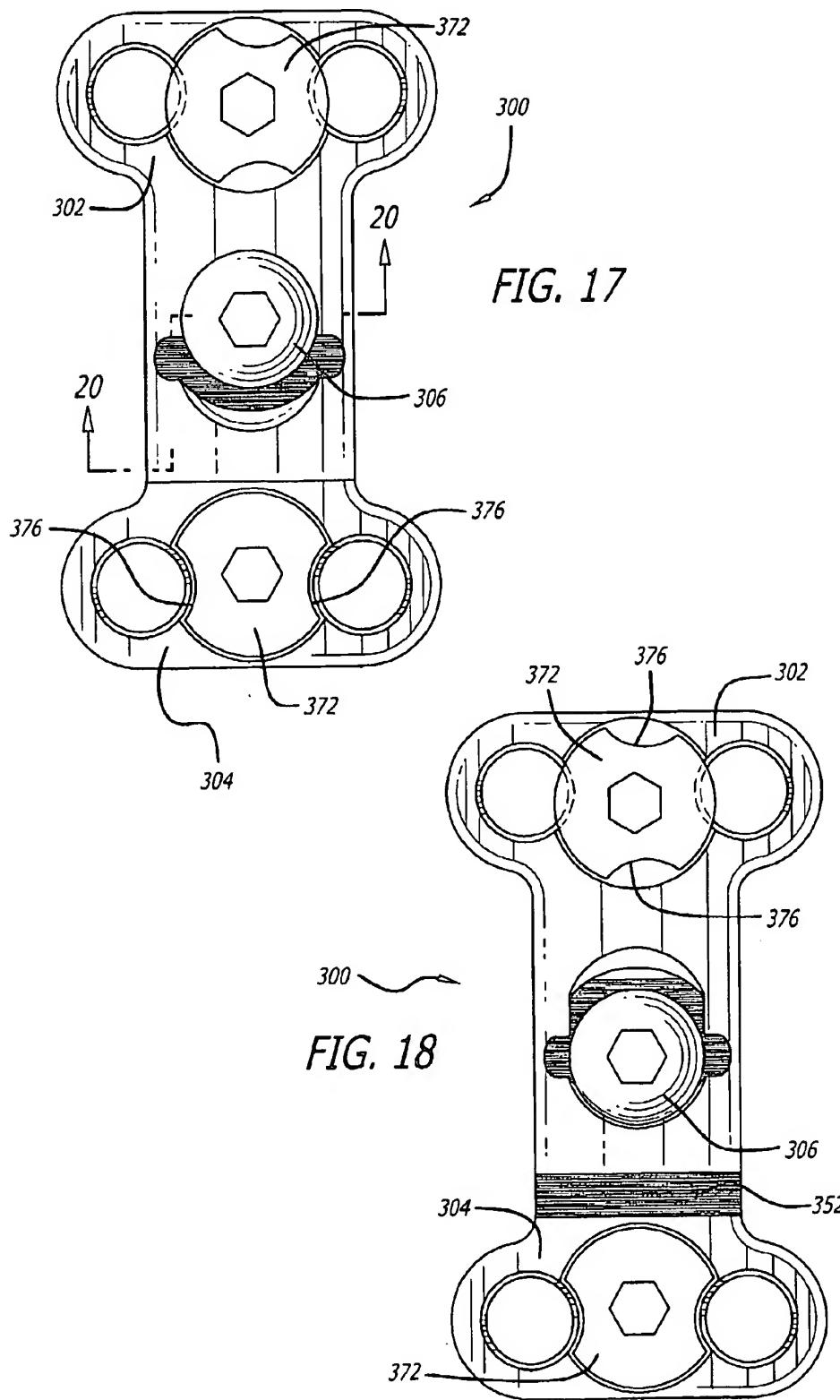


FIG. 16





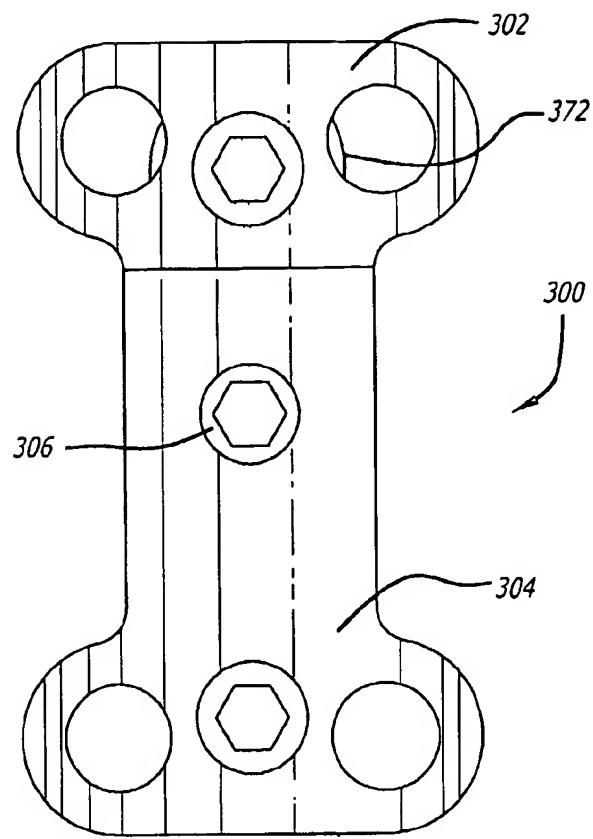


FIG. 19

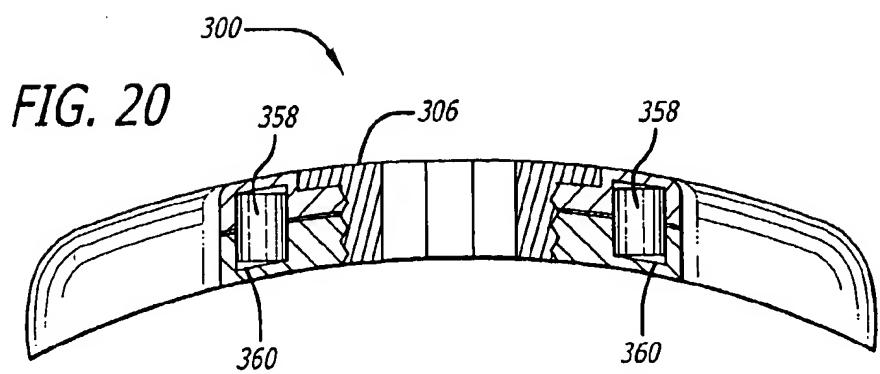
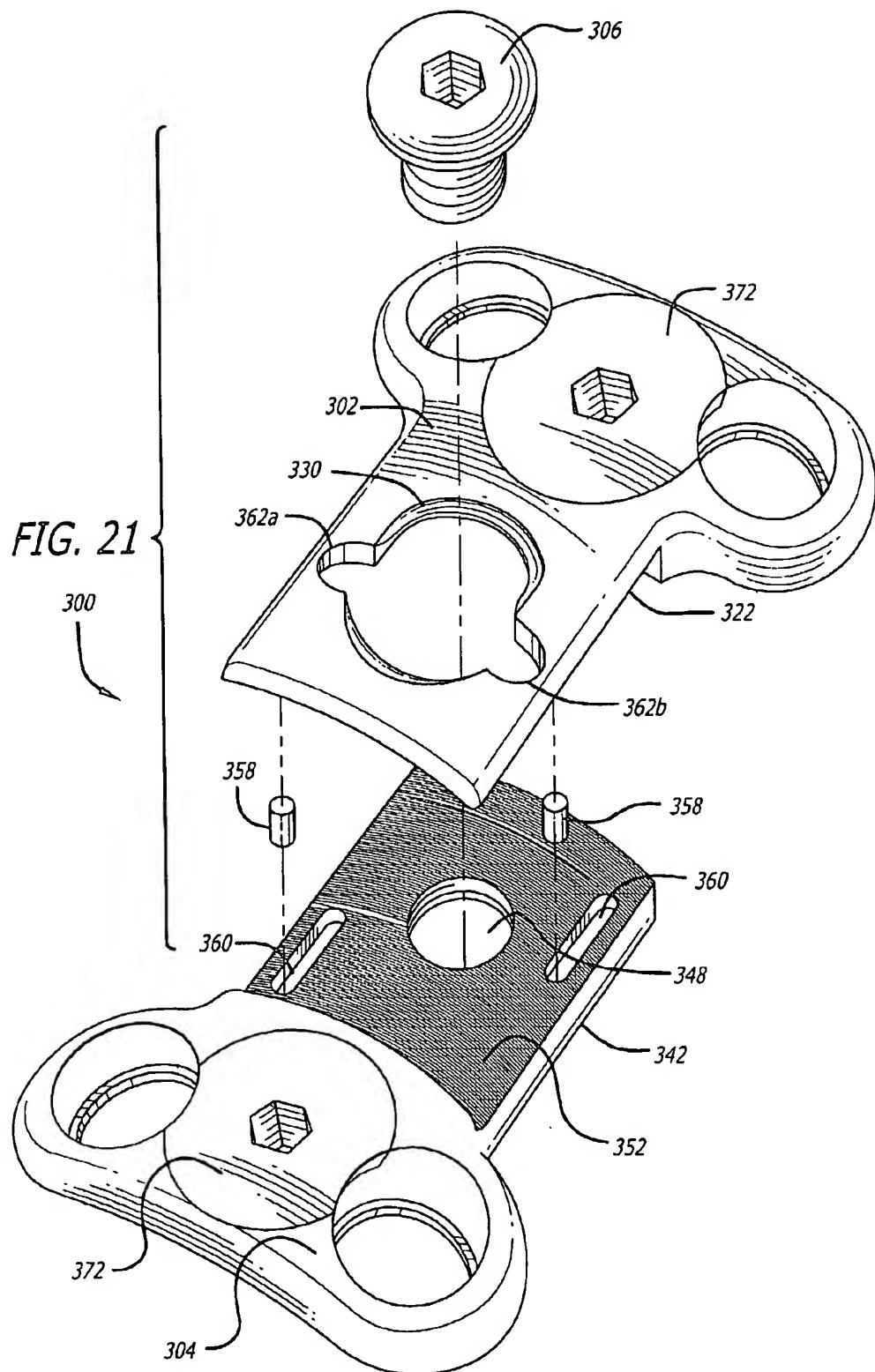
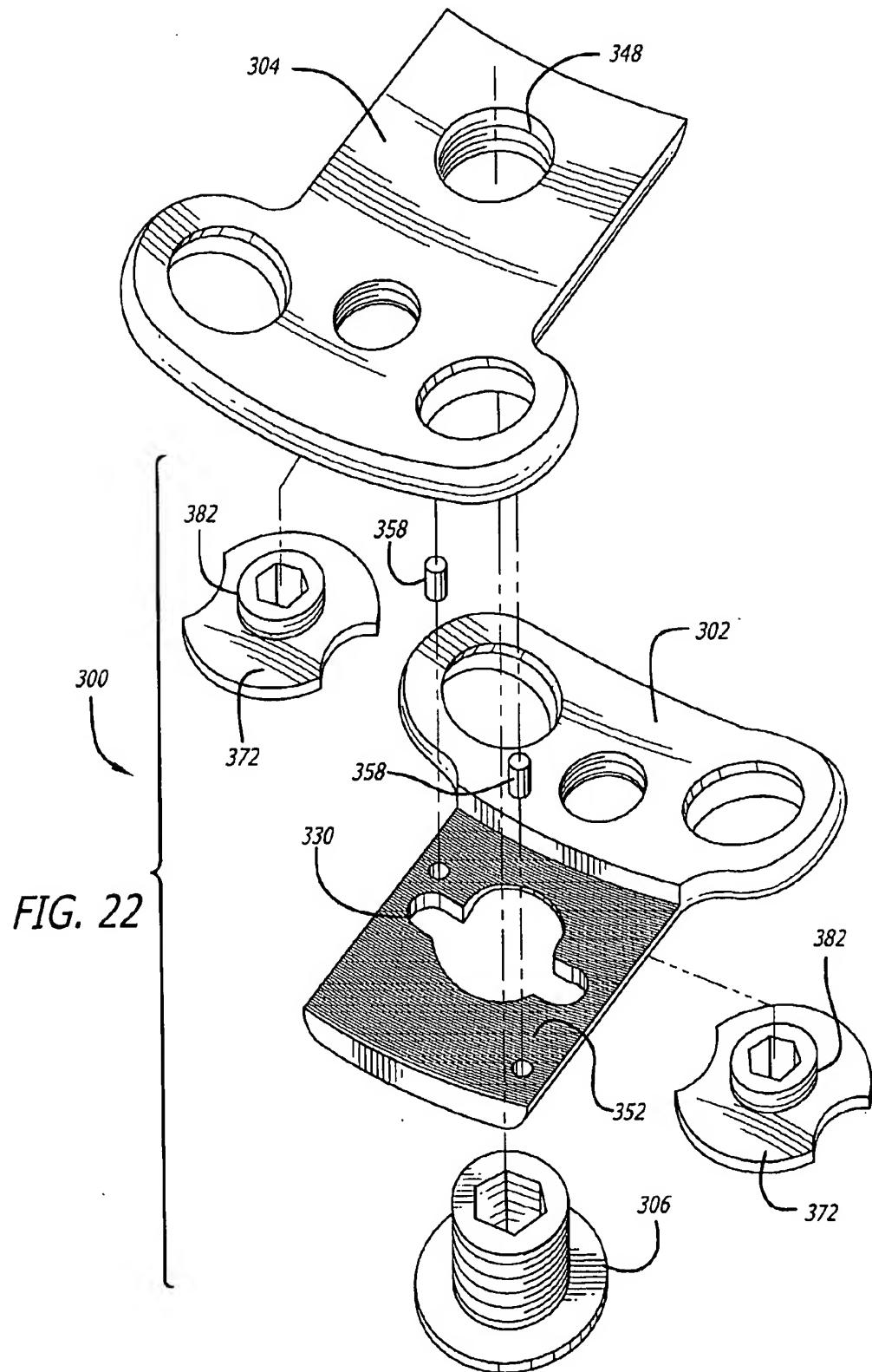
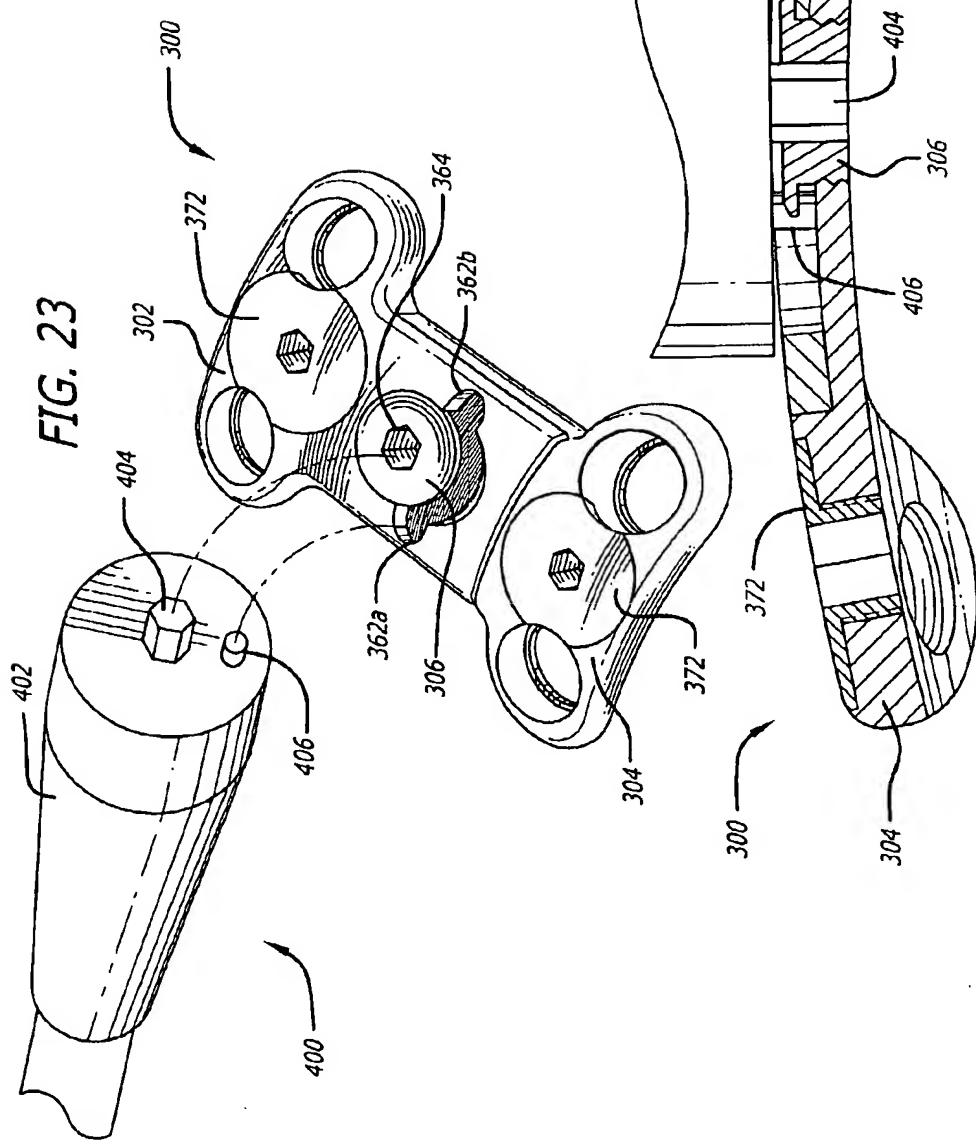
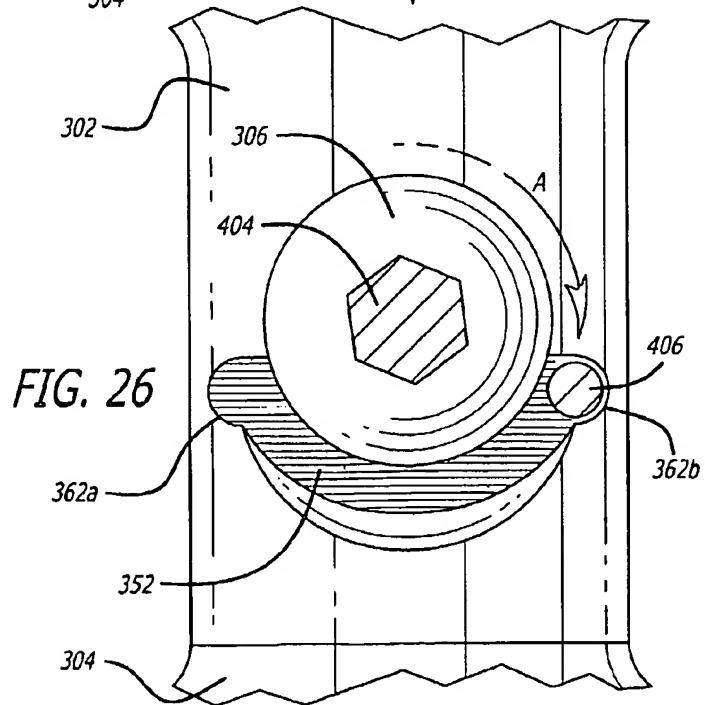
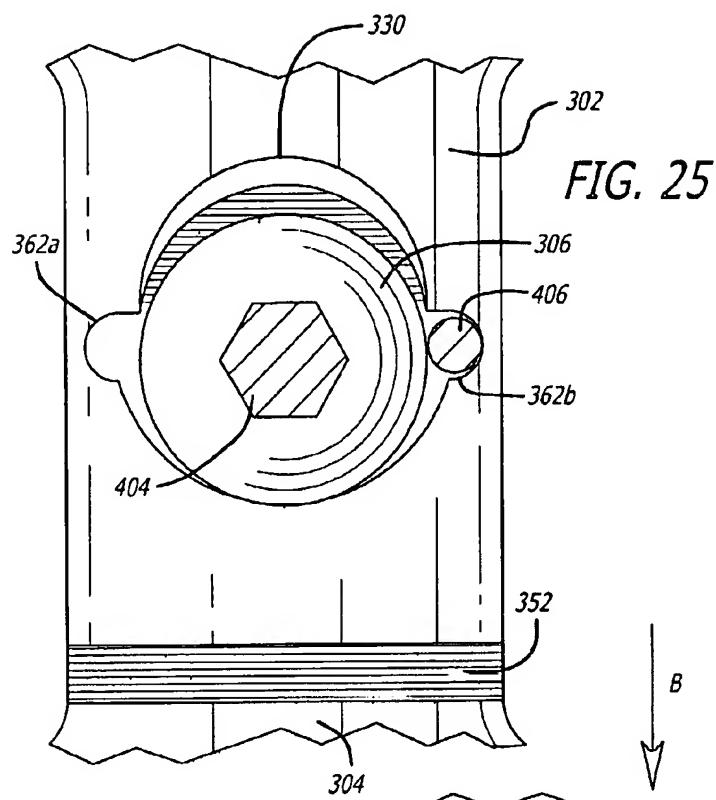


FIG. 20









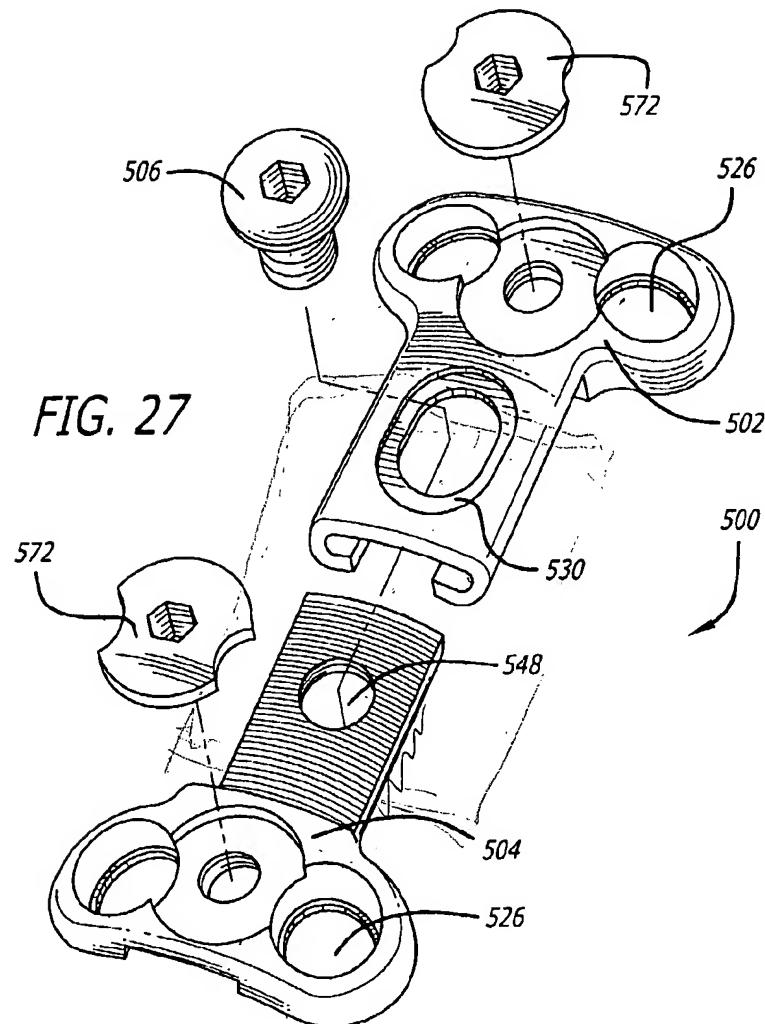
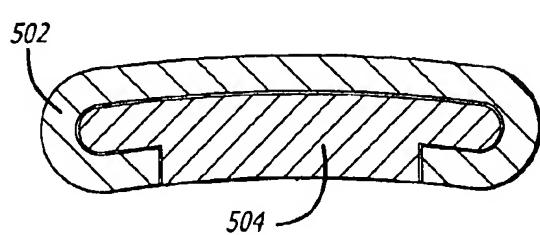
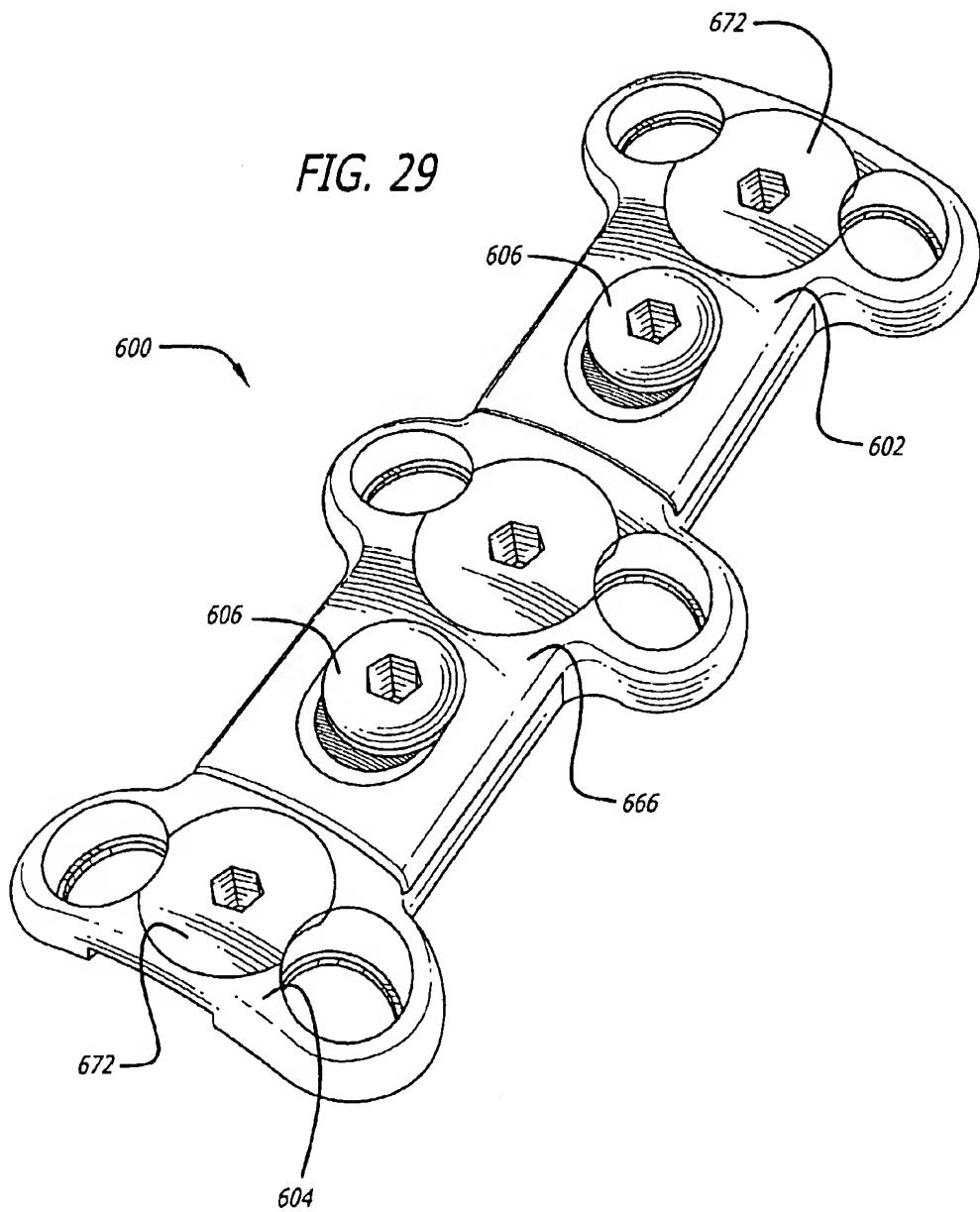


FIG. 28





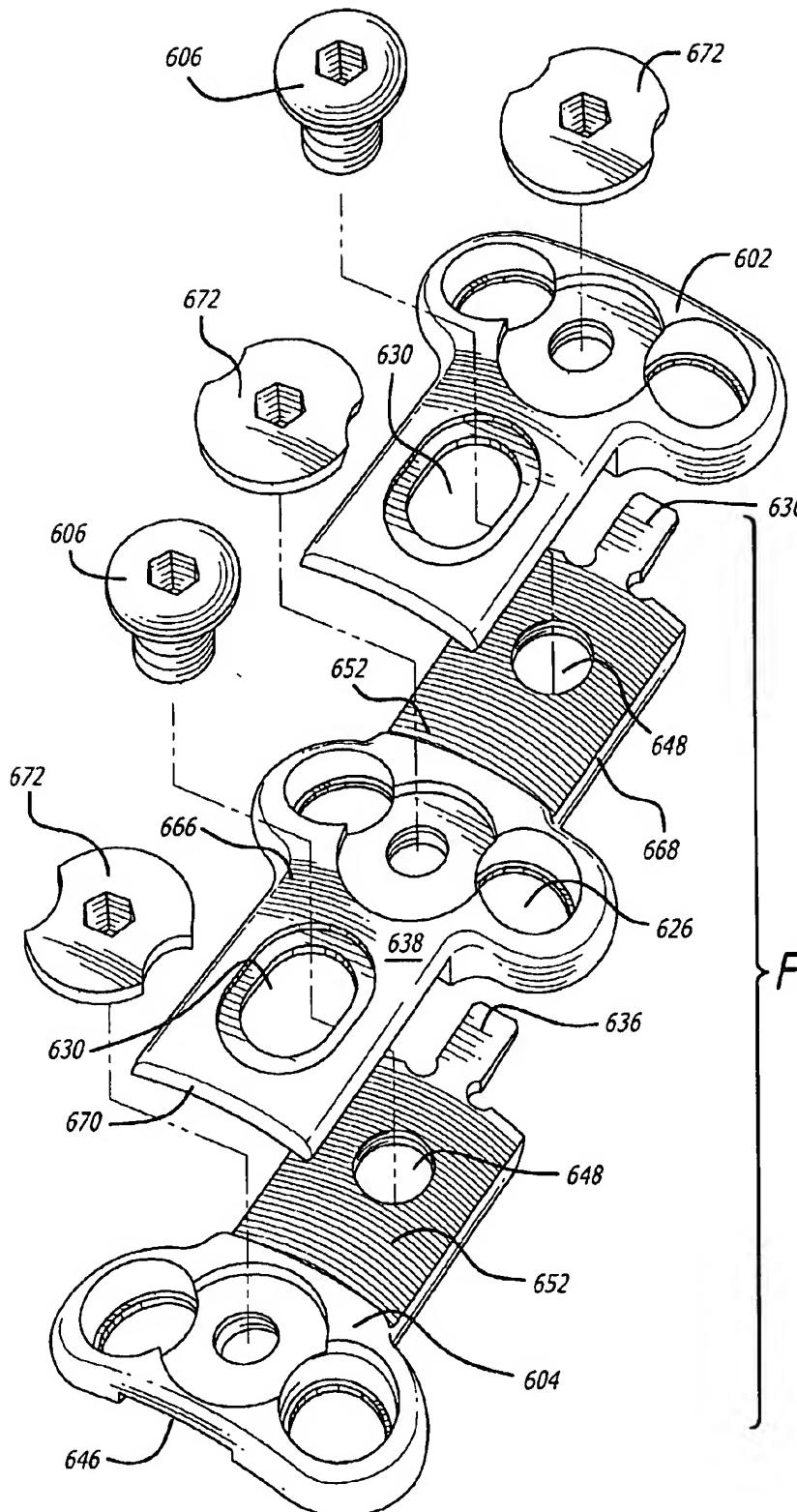
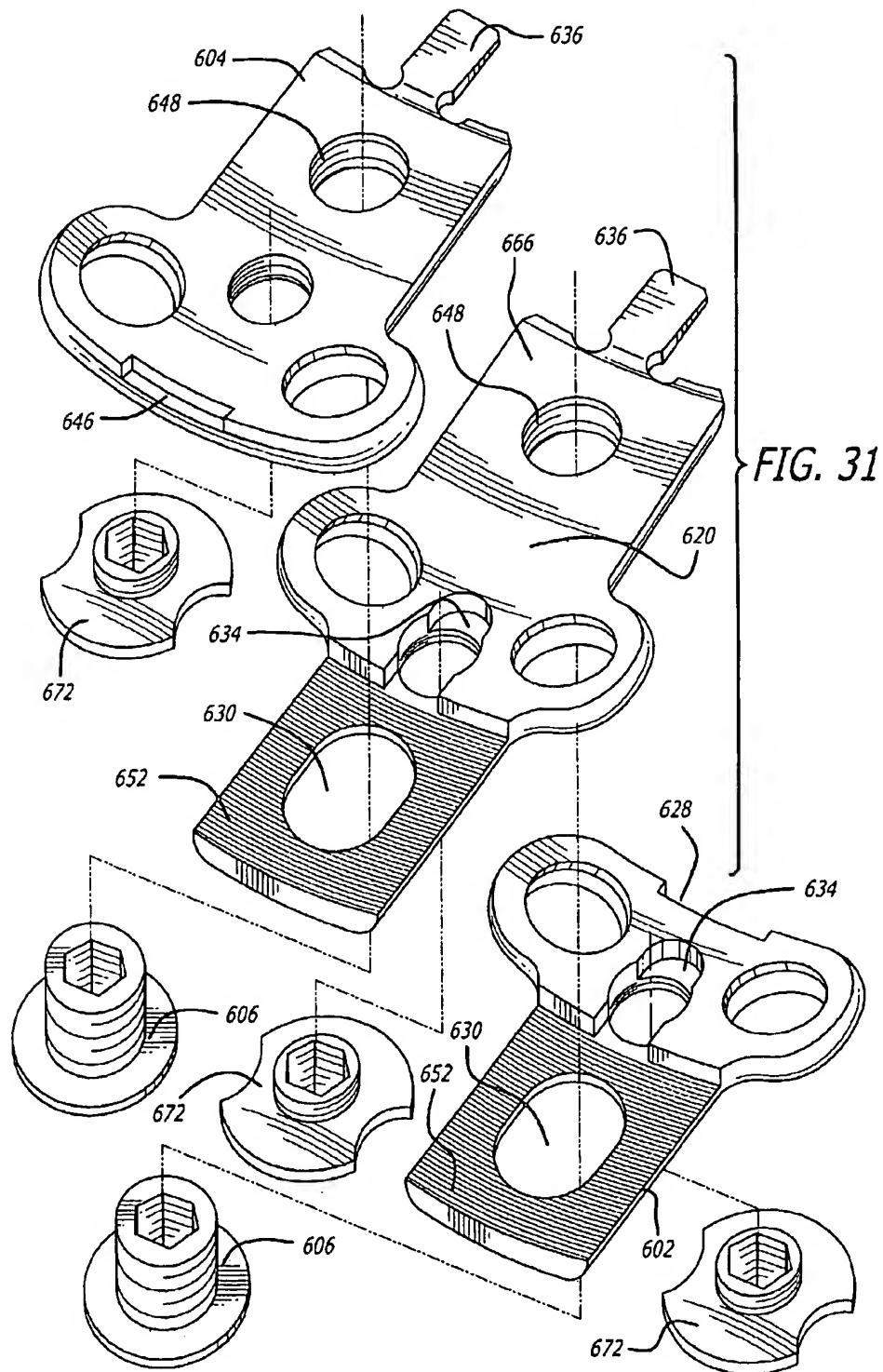
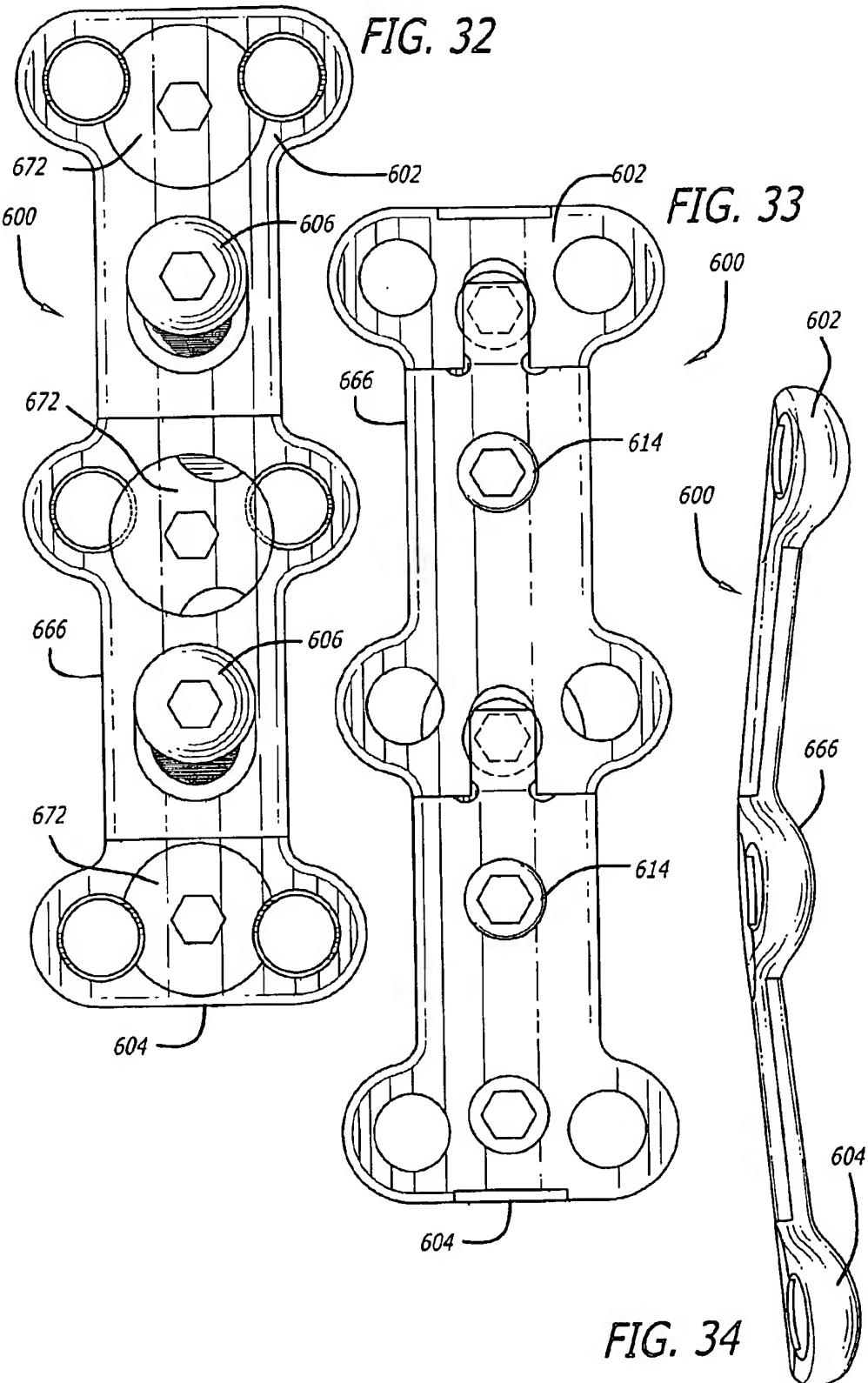
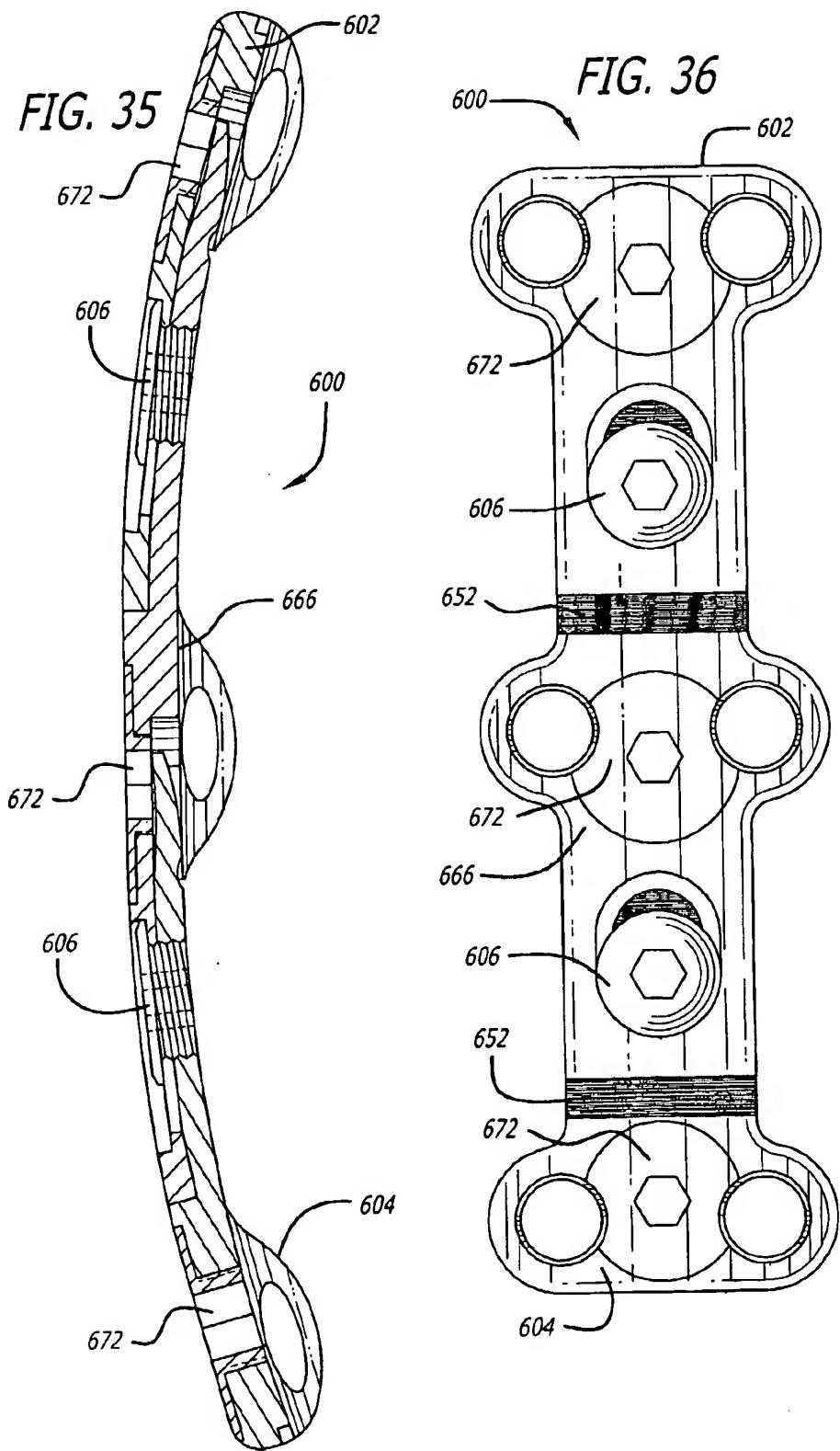


FIG. 30







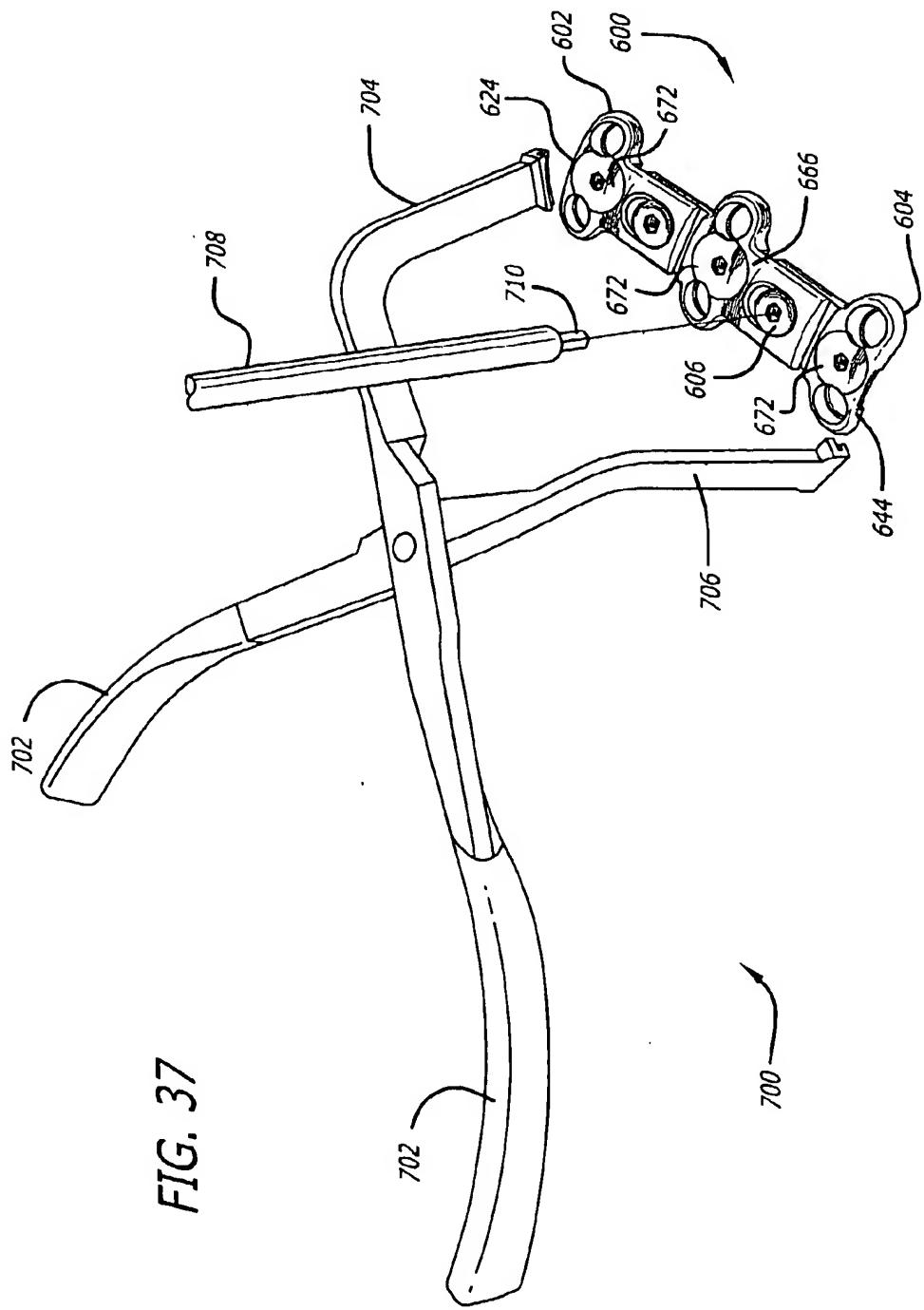
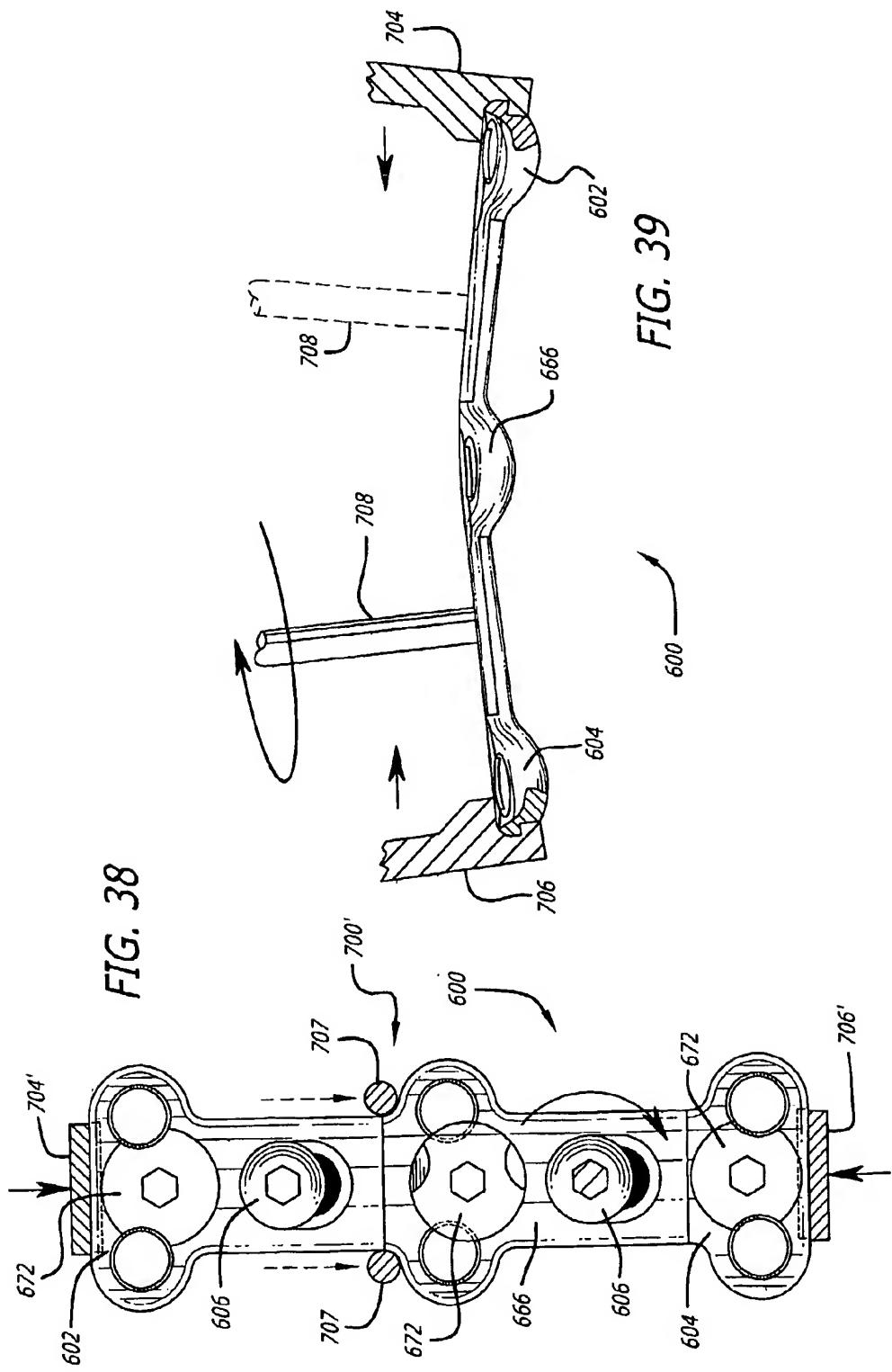
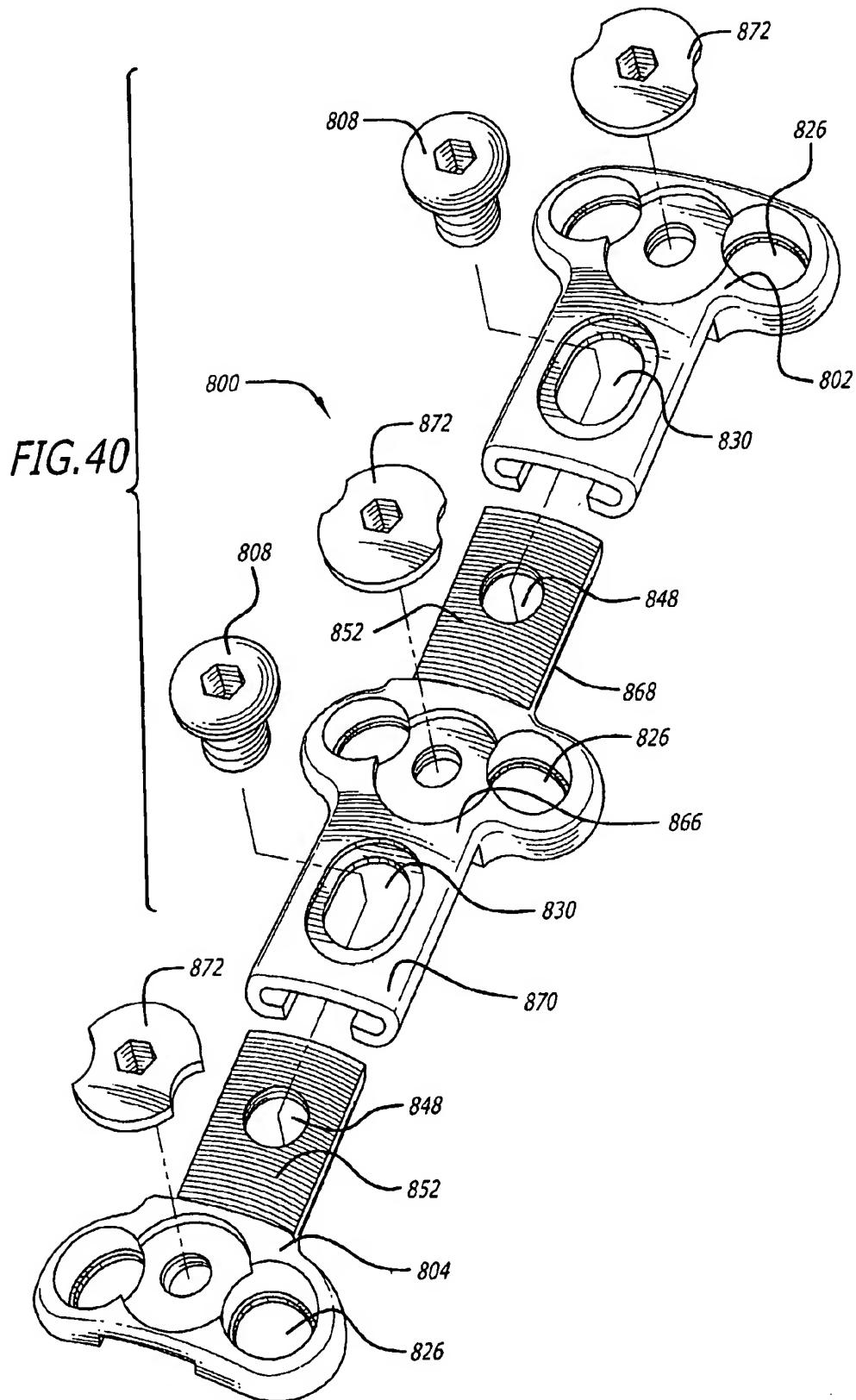
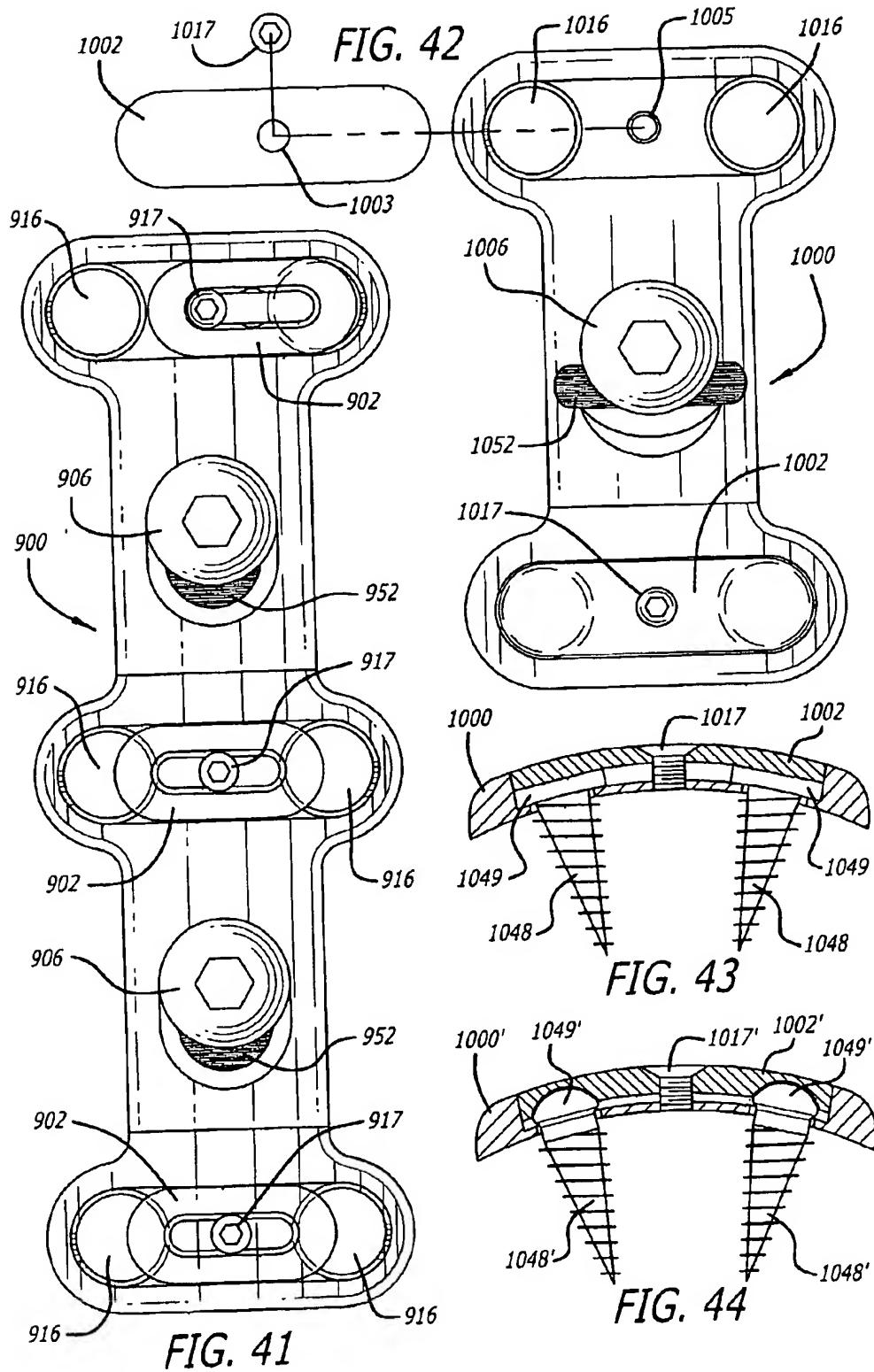


FIG. 37







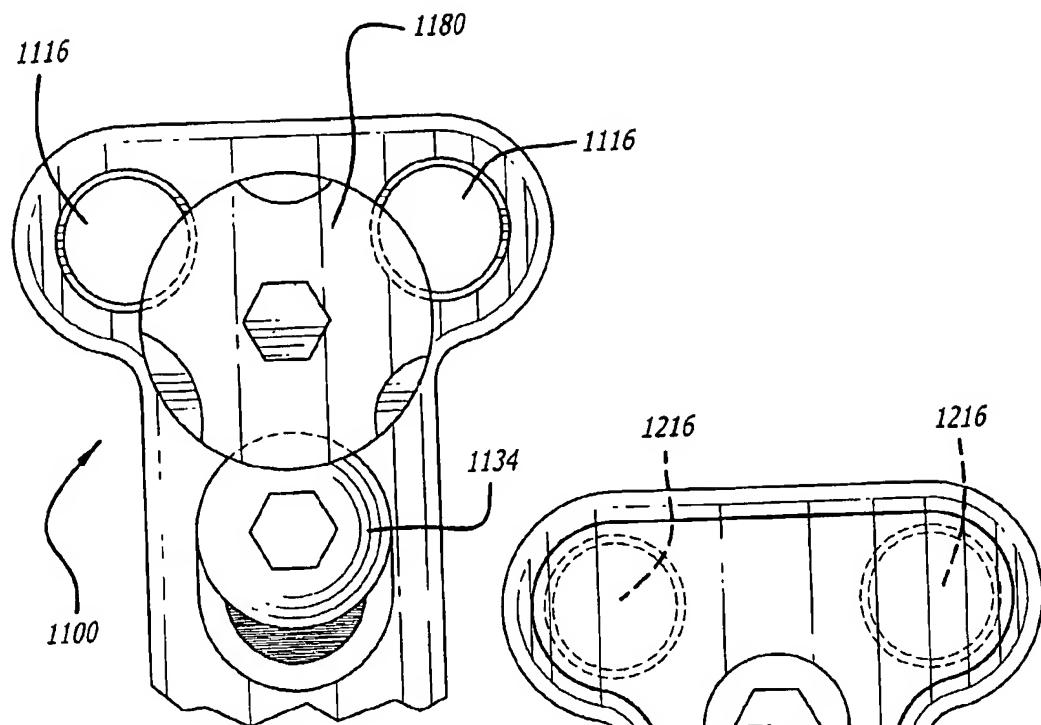


FIG. 45

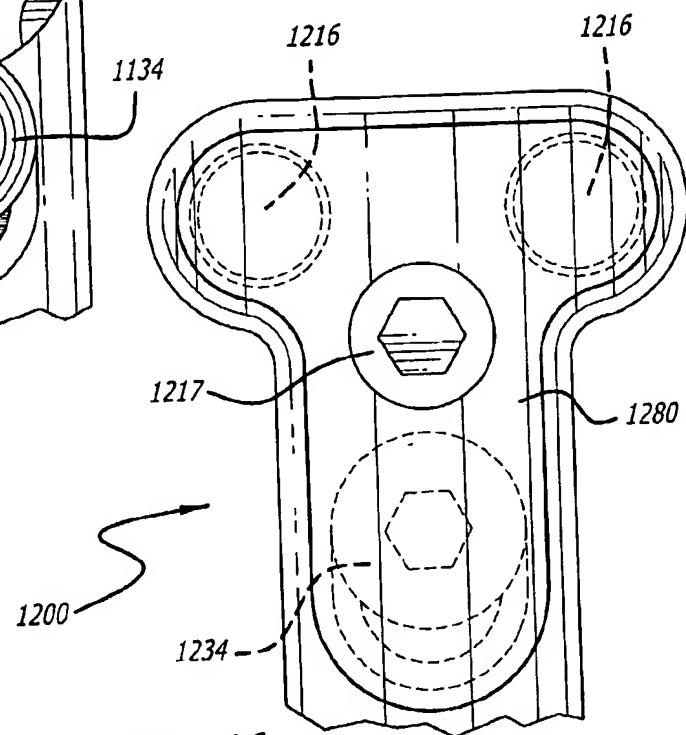


FIG. 46

**DYNAMIC, MODULAR, MULTILOCK ANTERIOR
CERVICAL PLATE SYSTEM HAVING
DETACHABLY FASTENED ASSEMBLEABLE AND
MOVEABLE SEGMENTS, INSTRUMENTATION,
AND METHOD FOR INSTALLATION THEREOF**

RELATED APPLICATIONS

[0001] This application claims the benefit of provisional application No. 60/296,680, filed Jun. 6, 2001, and provisional application No. 60/377,916, filed May 3, 2002, both of which are incorporated by reference herein.

BACKGROUND

[0002] The use of plates, screws, and locks to prevent separation and backing out of screws from the plate, for use on the anterior aspect of the cervical spine to provide alignment and stability as an adjunct to fusion of adjacent vertebral bodies is known in the art. Also known in the art is that compressive load, within a physiological range across a fusion site, is beneficial to the fusion process. Conversely, a failure to maintain a compressive load across a fusion site, or to have a gap in the fusion construct continuity may lead to a failure to achieve fusion called pseudoarthrosis. A primary purpose of the aforementioned cervical hardware is to provide stability during the healing and fusion process. The fusion process occurs in part through a process called "creeping substitution" by which new living bone replaces the dead bone such as that of a bone graft. The fusion process involves a phase of bone resorption as preliminary to the formation of the new bone. It is possible then for the bone resorption to result in gaps in the continuity of the fusion mass, such that if the hardware is sufficiently rigid, such as occurs as a result of increasing the strength of the components and constraining the relationship of the screws to the plate, those gaps may persist and increase in size as the hardware holds the bone portions separated rather than allowing those bone portions to move together to close those gaps. This holding apart of the bone portions (called distraction) can therefore lead to a failure of fusion (pseudoarthrosis). These rigid systems by a combination of not inducing compression at the fusion site and of holding the bone portions to be fused apart may cause a "distraction pseudoarthrosis."

[0003] Alternative cervical plating systems have attempted to prevent distraction pseudoarthrosis by allowing the vertebral bodies to collapse towards each other as needed during the fusion process. Generally this has been done by allowing the bone screws to be free to move relative to the plate, that is, movement such as sliding, swiveling, rotating, and angulating, independent of whether the screws are prevented from separating or backing out of the plates such as by the use of locks. Undesired multidirectional instability can occur in such plating systems that is counter to the very purpose of such hardware which is to increase or provide for stability.

[0004] Another approach to solving this problem has been to attach by screws a block to each of the vertebral bodies to be fused and then to allow those blocks to slide up and down on a pair of rods. Each of these constructs have in common that they sacrifice stability, the ability to hold the bones to be fused rigidly in place and prevent undesired motion; for the ability to allow, but not cause the vertebral bodies to collapse.

[0005] There exists therefore a need for an improved anterior cervical plating system that is: (1) sufficiently rigid to maintain the desired alignment of the vertebral bodies to be fused; (2) capable of inducing compressive load across the fusion site; and/or (3) capable of allowing for the motion of the vertebral bodies towards each other to prevent or to close any gaps in the continuity of the fusion construct, while still being capable of preventing motion in all other directions. When similar challenges have been faced at other skeletal locations, the solution involved anchoring the bone screws through the far cortex of the bone portions to be joined, in effect anchoring the screws in such a way as to make it possible for the screws to force movement of the plates. In the cervical spine anteriorly, however, it has been found to be highly undesirable to drive the bone screws through the far cortex of the vertebral bodies, as this is where the spinal cord is located. There remains therefore a need for an improved cervical plating system as just described that does not require that the bone screws penetrate the far cortex to achieve the desired purpose as described.

[0006] The size of the vertebral bodies and the spacing between the vertebral bodies varies from patient to patient. The height of the vertebral bodies and the discs therebetween may vary level by level even in the same person. Thus, a plate of correct length does not necessarily have bone screw receiving holes correctly positioned to overlie the vertebral bodies in accordance with the spacing of the vertebral bodies to which the plate is to be applied. As a result, conventional plating systems of the past had to be manufactured in many different lengths and spacing configurations which were nevertheless fixed in an attempt to provide plates for many, though still possibly not all, of the various sizes and spacings of the vertebral bodies to which the plate was to be applied. For example, in a multi-segment plate the length of the plate would need to correspond to the overall length of the vertebral bodies to be joined and actual distances therebetween and the screw holes of the plate arranged to overlie the vertebral bodies. In order to cover the possible range of sizes, health care facilities would need to carry a large inventory of different sizes of plates, in some cases as many as sixty different sized plates would be needed. Such a large inventory is an expensive undertaking and still worse, facilities with a high caseload need to invest in more than one of each plate size to provide for the possibility of overlapping demand for the same plate size. Facilities with lower caseloads may find it prohibitively expensive to stock an inventory of plates sufficient to cover the range of possible sizes and thus might not be able to afford to stock a set at all or have less than all sizes of plates needed for all cases. Manufacturers cannot afford to place a set of plates on consignment in facilities with low caseloads as the number of sales would not cover the carrying costs of the plates.

[0007] There exists therefore a need for an improved anterior cervical plating system that (1) allows for the overall adjustability of the length of the plate; (2) allows for variations in spacing between the bone screw receiving holes of the plate portions corresponding to the attachment point of the plate to the vertebral bodies; (3) reduces the requisite plate inventory; and (4) can avoid or prevent distraction pseudoarthrosis without itself introducing multidirectional instability.

SUMMARY OF THE INVENTION

[0008] The present invention is a dynamic, modular, anterior cervical plating system including a plate comprising assembleable segments in moveable relationship to each other adapted to allow for the overall adjustability of the length of the plate and for variations in the intersegmental spacing of the bone screw receiving holes, create and/or store a compressive load across a disc space between two adjacent vertebral bodies to be fused, and/or allow motion of the vertebral bodies toward each other to prevent or close gaps in the continuity of a fusion construct, while preferably preventing motion in all other directions when in use. As used herein, a spinal fusion segment is defined as two vertebral bodies with an intervertebral implant, made of bone or an artificial material, in the disc space therebetween. As used herein, a fusion construct is defined as a spinal fusion segment plus the hardware, such as a plate and screws for example.

[0009] The ability to permit the movement of adjacent vertebral bodies toward one another is referred to herein as "dynamization." Dynamization may be "passive" allowing the plate to shorten when a shortening force, such as a compressive load is applied. Dynamization may be "active" wherein the plating system stores energy to induce shortening of the fusion construct should the opportunity present. The present invention plating system may passively dynamize, actively dynamize, provide a combination of both, as well as convert and store certain compressive stresses encountered during the healing phase as will be more fully described herein.

[0010] The plate segments can also be moved to vary the spacing between the plate segments as well as the overall length of the plate so that the size of the plate may be adjusted to correspond to a range of sizes and spacing of the adjacent vertebral bodies to which the plate is being applied thereby greatly reducing the inventory of plate sizes needed. The moveable plate segments combine to form the plate. Each plate segment is attached to a vertebral body to be fused by at least one bone screw and preferably a pair of bone screws, which when inserted, are preferably prevented from backing out of the plate by at least one locking element adapted to lock at least two bone screws to the plate.

[0011] The paths of the bone screws through the plate may be fixed or variable. If the paths are variable, they may be more or less stable depending on how resistant to motion the screws are relative to the plate when the screws are locked to the plate. To the extent that screws are sufficiently stable in relation to the plate to make use of the present inventive teaching, these screw, plate, and lock combinations or variations thereon are also within the broad scope of the present invention.

[0012] In a first embodiment of the present invention, after each of the segments of the plate are attached to a respective one of the vertebral bodies to be fused, the plate is capable of movement from a first or elongated position to a second or shorter position, a process generally referred to as "passive dynamization"—that is the ability of the system to allow the plated spinal segment to shorten in response to unmet compressive loads to allow for the bone portions to be fused to move close together to restore contact. A preferred embodiment of this present invention is capable of allowing for this passive dynamization while preventing undesirable

motions along and around all axes other than the motion along the longitudinal axis of the plate.

[0013] In another preferred embodiment of the present invention, the plate segments are articulated in such a way that even the one freedom of movement that is along the longitudinal axis of the plate is selectively limited to the desired passive dynamization that is shortening of the plate construct. This preferred embodiment of the present invention will shorten as required to maintain loaded contact of the bone portions to be fused, and if challenged, resist any forces such as those that would accompany cervical extension that would distract or destabilize the construct by elongating it. A further benefit of this embodiment is its ability to store and impart a compressive load across the fusion site referred to herein as "active dynamization" wherein energy stored in the system shortens the plate construct if conditions permit. This load can be applied by the surgeon at the time of surgery and/or be produced during the healing phase by harnessing the compressive loads such as occur randomly with neck motion. Compressive load within a physiological range has been shown to have a beneficial effect on the healing of bone. The induction of a compressive load across vertebral bodies to be fused, induces bone growth and when bone resorption occurs at the interface of the graft or implant and the vertebral bodies to be joined, those vertebral bodies are urged to move closer together, thus avoiding the formation of a gap therebetween and thereby acting to mitigate against pseudoarthrosis.

[0014] Alternatively, various embodiments of the present invention allow the surgeon to induce a desired amount of preload (compressive force) across the fusion site and to permit a desired amount of shortening of the construct—"active dynamization" should the opportunity occur; and yet lock the system to prevent any further shortening as might present a risk of deformity or be otherwise undesirable. Such a system urges the bone portions closer together.

[0015] In a preferred embodiment, a pre-load force can be applied to the plate segments such that while the plate segments may undergo no added motion initially, there is a selective force applied to the plate segments and the plate segments are capable of motion in only one direction, such that should resorption occur at one of the fusion interfaces then the plate segments are not only free to move in a direction toward one another, and only in that direction, but are also urged to do so to relieve that preload force. Such a system urges the vertebral bodies together over time as resorption permits.

[0016] Alternatively, in another embodiment of the plate of the present invention, a desired amount of preload (compressive force) may be induced across the fusion site to permit active dynamization should the opportunity occur, without locking the system such that after active dynamization is exhausted (if exhausted), then the plate will still allow passive dynamization to occur thereafter.

[0017] In another embodiment of the present invention, the plate includes a structural feature such as a groove, recess, slot, cam, or pivot, within its physical perimeter to engage a tool to cooperatively move segments of the plate towards each other. These embodiments of the present invention may be adapted to allow for passive, active, or active plus passive dynamization, and when used to store compressive load to allow for or prevent further motion

thereafter. In a preferred version of the this embodiment, the structural feature contained within the plate for generating the compressive load and/or shortening the plate, may also serve as the locking mechanism to limit the amount of further shortening possible.

[0018] Various embodiments of the plating system of the present invention provide one or more of the following advantages:

[0019] 1. Reduces the requisite plate inventory as each plate may cover a range of sizes. The plate of the present invention includes multiple segments which may be of varying sizes wherein the segments are adapted to be assembled so as to be adjustable to provide for the size and spacing apart of the vertebral bodies to which the plate is to be applied. The plate may have its segments moved relative to one another so that the spacing between the plate segments may be adjusted so as to correspond to the actual distances between the vertebral bodies to be fused in a multi-segment construct for a more precise fit. The height of the discs and the vertebral bodies may vary level by level even in the same person. Thus, the ability to adjust the distances between the segments of the plates that correspond to the attachments to those vertebral bodies allows for a more precise fit of the plate to the spine with a reduced inventory of the number of plates required to do so.

[0020] 2. It is possible to precisely contour each segment separately.

[0021] 3. Reduces the risk that the plate construct will be discovered to be too short or too long after the attachment process has commenced.

[0022] 4. It is possible to compress and dynamize levels selectively.

[0023] 5. The fasteners that link the segments can be tightened to lock the segments after they are compressed or, alternatively, can allow for further motion of the plate segments together.

[0024] 6. The same hardware can provide for passive dynamization or be rigidly fixed depending on the fasteners used to link plate segments.

[0025] 7. The system can allow for passive dynamization, active dynamization, the combination of passive and active dynamization, or can convert body motion into active dynamization.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. 1 is an exploded top perspective view of a plate, a fastener, and locking elements in accordance with a preferred embodiment of the present invention.

[0027] FIG. 2 is an exploded bottom perspective view of the plate, fastener, and locking elements of FIG. 1.

[0028] FIG. 3 is a top plan view of the plate, fastener, and locking elements of FIG. 1.

[0029] FIG. 4 is a bottom plan view of the plate, fastener, and locking elements of FIG. 1.

[0030] FIG. 5 is an end view of the plate of FIG. 1.

[0031] FIG. 6 is a side elevation view of the plate of FIG. 1.

[0032] FIG. 7 is a partial cross sectional view of the plate of FIG. 1.

[0033] FIG. 8 is an enlarged fragmentary view of the plate of FIG. 1 and an alternative embodiment of a fastener in accordance with the present invention.

[0034] FIG. 9 is an enlarged fragmentary cross sectional view of an embodiment of the ratcheting in the upper and lower portions of the plate of FIG. 1 in a first position.

[0035] FIG. 10 is a fragmentary cross sectional view of FIG. 9 in a second position.

[0036] FIG. 11 is an enlarged fragmentary cross sectional view of a preferred embodiment of the ratcheting in the upper and lower portions of the plates of the present invention in a first position.

[0037] FIG. 12 is a fragmentary cross sectional view of FIG. 11 in a second position.

[0038] FIG. 13 is a top perspective view of the plate and fastener of FIG. 1 and instrumentation for compressing the plate and instrumentation for locking the fastener in accordance with a preferred embodiment of the present invention.

[0039] FIG. 14 is a top plan view of the plate and fastener of FIG. 1 in a compressed state with the instrumentation of FIG. 13 shown in cross section engaging the ends of the plate to compress the plate in the direction of the arrows and with the instrumentation engaging the fastener.

[0040] FIG. 15 is a partial cross sectional view along line 15-15 of FIG. 14.

[0041] FIG. 16 is a top perspective view of a plate, a fastener, and locking elements in accordance with another preferred embodiment of the present invention.

[0042] FIG. 17 is a top plan view of the plate, fastener, and locking elements of FIG. 16.

[0043] FIG. 18 is a top plan view of the plate of FIG. 16 in an elongated state, fastener, and locking elements.

[0044] FIG. 19 is a bottom plan view of the plate and fastener of FIG. 16.

[0045] FIG. 20 is a partial cross sectional view along line 20-20 of the plate of FIG. 17.

[0046] FIG. 21 is an exploded top perspective view of the plate, fastener, and locking elements of FIG. 16.

[0047] FIG. 22 is an exploded bottom perspective view of the plate, fastener, and locking elements of FIG. 16.

[0048] FIG. 23 is a top plan view of the plate, fastener, and locking elements of FIG. 16 and a partial fragmentary perspective view of an instrument for compressing the plate and securing the fastener in accordance with another preferred embodiment of the present invention.

[0049] FIG. 24 is an enlarged cross sectional view of the plate of FIG. 16 with the instrument of FIG. 23 engaging the fastener and positioned within the plate.

[0050] FIG. 25 is a fragmentary top plan view of the plate of FIG. 16 in an elongated state with the instrument of FIG. 23 shown in cross section engaging the fastener and positioned within the plate.

[0051] FIG. 26 is a fragmentary top plan view of the plate of FIG. 16 in a compressed state with the instrument of FIG. 23 shown in cross section engaging the fastener and positioned within the plate to rotate the fastener in the direction of the arrow to compress the plate.

[0052] FIG. 27 is an exploded top perspective view of a plate, a fastener, and locking elements in accordance with another preferred embodiment of the present invention.

[0053] FIG. 28 is a cross sectional view transverse to the longitudinal axis of the plate of FIG. 27.

[0054] FIG. 29 is a top plan view of a plate, fasteners, and locking elements in accordance with another preferred embodiment of the present invention.

[0055] FIG. 30 is an exploded top perspective view of the plate, fasteners, and locking elements of FIG. 29.

[0056] FIG. 31 is an exploded bottom perspective view of the plate, fasteners, and locking elements of FIG. 29.

[0057] FIG. 32 is a top plan view of the plate, fasteners, and locking elements of FIG. 29.

[0058] FIG. 33 is a bottom plan view of the plate, fasteners, and locking elements of FIG. 29.

[0059] FIG. 34 is a side elevation view of the plate of FIG. 29.

[0060] FIG. 35 is a partial cross sectional view along the longitudinal axis of the plate of FIG. 29.

[0061] FIG. 36 is a top plan view of the plate in an elongated position, fasteners, and locking elements of FIG. 29.

[0062] FIG. 37 is a top perspective view of the plate of FIG. 29 and another preferred embodiment of instrumentation for compressing the plate and instrumentation for locking the fastener in accordance with the present invention.

[0063] FIG. 38 is a top plan view of the plate of FIG. 29 in a compressed state with the instrumentation of FIG. 37 shown in cross section engaging the ends of the plate to compress the plate in the direction of the arrows, an alternative embodiment of instrumentation for engaging an intermediary portion of the plate to compress the plate in the direction of the arrows in dotted line, and instrumentation engaging the fastener and positioned within the plate.

[0064] FIG. 39 is a side elevation view of the plate of FIG. 38 with the instrumentation shown in partial fragmentary, hidden line, and cross sectional views.

[0065] FIG. 40 is an exploded top perspective view of a plate, fasteners, and locking elements in accordance with another preferred embodiment of the present invention.

[0066] FIG. 41 is a top plan view of a plate, fasteners, and locking elements in accordance with another preferred embodiment of the present invention.

[0067] FIG. 42 is a top plan view of a plate, fasteners, and locking elements in accordance with another preferred embodiment of the present invention.

[0068] FIG. 43 is an enlarged fragmentary cross sectional view of the plate, locking element, and bone screws of FIG. 42.

[0069] FIG. 44 is an enlarged fragmentary cross sectional view of a plate, locking element, and bone screws in accordance with another embodiment of the present invention.

[0070] FIG. 45 is a fragmentary top plan view of another preferred embodiment of a plate and a locking element adapted to lock at least two bone screws and a fastener in accordance with the present invention.

[0071] FIG. 46 is a fragmentary top plan view of another preferred embodiment of a plate and a locking element adapted to lock at least two bone screws and a fastener in accordance with the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0072] Reference will now be made in detail to the present preferred embodiments (exemplary embodiments) of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0073] The present invention is for use in the cervical spine where dynamization is highly desired to prevent distraction pseudoarthrosis and to maintain a compressive load across the fusion interfaces. The present invention in one preferred embodiment is directed to a cervical plate generally having at least two movable segments that are attached to the vertebral bodies to be fused and connected in such a way as to permit dynamization of the vertebral bodies preferably along the longitudinal axis of the plate. The movement of the segments relative to one another may be accompanied by a reduction in the overall length of the plate.

[0074] FIGS. 1-7 show a preferred embodiment of a cervical plate 100 in accordance with the present invention. Plate 100 is preferably formed of a first segment 102 and a second segment 104 in moveable relationship to one another. First and second segments 102, 104 can be of various lengths and/or configurations such that when the segments are assembled preferably overlapping at least in part, plates of various lengths and/or configurations can be formed to cover a range of sizes. First and second segments 102, 104 can be of the same or different lengths and can be coupled to each other or to an intermediate segment as shown in FIGS. 29-40 and described below in connection with other preferred embodiments of the present invention. The overall length of plate 100 and the spacing of segments 102, 104 can be adjusted by moving segments 102, 104 relative to one another.

[0075] A detachable fastener 106 couples together first and second segments 102, 104. Fastener 106 is configured to be detachably attached to at least one of first and second segments 102, 104 to permit the assembly of two or more plate segments. Fastener 106 is detachable to permit for the assembly of the plate segments by the surgeon and allows

for the complete uncoupling of first and second segments 102, 104 from one another. As used herein, "detachable fastener" is defined as a fastener that can be assembled by the surgeon at the time of use and once attached is meant to still be removable and then reattachable by the surgeon. As shown in FIG. 7, fastener 106, for example, may be embodied in the form of a screw having a head 108, a shaft 112, and a thread 116.

[0076] As shown in FIG. 8, in another preferred embodiment fastener 106' may be configured to be tightened to only one of first and second plate segments 102, 104 so as to permit movement of first and second segments 102, 104 relative to one another when fastener 106' is fully tightened. For example, fastener 106' may have a shoulder 110 adapted to bear upon second segment 104 as indicated by arrow C. Shoulder 110 is dimensioned so as to create a gap 111 between head 108' and first segment 102 so as to still permit a specific and desired motion of first and second segments 102, 104 relative to one another when fastener 106' is fully tightened. The limited motion of first and second segments 102, 104 relative to one another provides for dynamization of the spinal segment to be fused in that those vertebral bodies are allowed to move closer together to maintain contact.

[0077] As shown in FIGS. 1 and 2, first segment 102 preferably has an upper surface 118, a lower surface 120, a medial portion 122, and an end 124. First segment 102 preferably includes bone screw receiving holes 126 proximate end 124. Bone screw receiving hole 126 is preferably configured to receive a single bone screw or the bone screw receiving holes also may be configured to receive more than one bone screw. By way of example only and not limitation, a bone screw receiving hole may be in the form of a slot sized to receive at least two bone screws.

[0078] Preferably, at least two of bone screw receiving holes 126 may be oriented in plate 100 to overlie the anterior aspect of a single cervical vertebral body adjacent a disc space to be fused, though the invention is not so limited. For example, a first pair of bone screw receiving holes 126 may be configured to overlie the anterior aspect of a first cervical vertebral body adjacent a disc space to be fused and at least a second pair of bone screw receiving holes 126 may be oriented in plate 100 to overlie the anterior aspect of a second cervical vertebral body adjacent the disc space to be fused.

[0079] Bone screw receiving hole 126 may, though need not be, configured to form an interference fit with at least a portion of the trailing end of a properly dimensioned bone screw to be received therein. Bone screw receiving holes 126 may be configured, for example only, so that at least one of bone screw receiving holes 126 may hold a bone screw in a fixed relationship to the plate or may hold a bone screw in a moveable relationship, such as a variable angular relationship, described below. By way of example only and not limitation, bone screw receiving hole 126 may have a reduced dimension proximate lower surface 120 of segment 102 to form a seat 127. Seat 127 may have a surface adapted to contact at least a portion of a bone screw inserted therein. The surface may be at least in part planar, at least in part curved, or have any other configuration suitable for contacting at least a portion of a bone screw.

[0080] End 124 of first segment 102 may also include a tool engagement area 128 adapted to cooperatively engage

instrumentation for holding plate 100 and instrumentation for moving first and second segments relative to one another to induce a desired amount of compressive force across the fusion sites and to permit a desired amount of shortening of plate 100. Medial portion 122 preferably has a fastener receiving opening 130 adapted to accommodate fastener 106 to couple first and second segments 102, 104 to one another.

[0081] Fastener receiving opening 130 is preferably configured to permit selected movement of fastener 106 therein and to permit selected motion of first and second segments 102, 104 along the longitudinal axis of plate 100. Fastener receiving opening 130 may include a shoulder 132 recessed from upper surface 118 of first segment 102 adapted to contact the underside of head 108 of fastener 106 in the tightened position to prevent movement of first and second segments 102, 104 relative to one another. Alternatively, if a fastener 106' is used, shoulder 110 contacts second segment 104 and the underside of head 108' is positioned relative to shoulder 132 to permit movement of first and second segments 102, 104 relative to each other along the longitudinal axis of the plate when in the tightened position providing for dynamization of the vertebral bodies to be fused to occur, if needed. Fastener 106 and fastener receiving opening 130 cooperate to prevent complete uncoupling of first and second segments 102, 104 from one another when fastener 106 is installed. For example, fastener receiving opening 130 may be configured to prevent head 108 of fastener 106 from passing therethrough.

[0082] Lower surface 120 of first segment 102 includes a tab receiving recess 134 for receiving a tab 136 described below.

[0083] Second segment 104 has an upper surface 138, a lower surface 140, a medial portion 142, and an end 144. Second segment 104 preferably has bone screw receiving holes 126 proximate end 144. End 144 may also include a tool engagement area 146 adapted to cooperatively engage instrumentation for holding plate 100 and instrumentation for moving first and second segments 102, 104 relative to one another to induce a desired amount of compressive force across the fusion site and to permit a desired amount of shortening of plate 100. Medial portion 142 preferably includes a fastener receiving opening 148 for receiving a portion of fastener 106. As first and second segments of plate 100 are modular and assembleable, fastener receiving opening 148 is configured to permit detachable attachment of fastener 106.

[0084] Fastener receiving opening 148 preferably has a thread 150 adapted to engage with thread 116 of fastener 106. The threaded engagement of fastener 106 to fastener receiving opening 148 permits first segment 102 and second segment 104 to be attached to each other when fastener 106 is sufficiently rotated and tightened. As fastener 106 is rotated further, first and second segments 102, 104 are secured together and locked and do not move relative to each other. Alternatively, if fastener 106' shown in FIG. 8 is used in the tightened position, first and second segments 102, 104 are capable of moving relative to each other.

[0085] Lower surfaces 120, 140 of first and second segments 102, 104 are preferably at least in part concave along at least a portion of the longitudinal axis of the plate, may be biconcave at least in part, that is, concave along the longitudinal axis of plate 100 and concave transverse to the

longitudinal axis of the plate, or may have any shape suitable for the intended purpose transverse to the longitudinal axis of the plate. A person skilled in the art will appreciate that plate 100 may be adapted for other curvatures or have no curvature without departing from the intended purpose within the broad scope of the present invention. Lower surfaces 120,140 are preferably adapted to contact at least a portion of the vertebral bodies to be fused and may be configured to conform to the anterior aspect of at least a portion of the vertebral bodies.

[0086] Second segment 104 preferably includes a tab 136 extending from medial portion 142. Tab 136 is configured to cooperatively engage a tab receiving recess 134 in the lower surface 120 of first segment 102. Tab 136 acts as a spring to maintain first and second segments 102,104 aligned along the longitudinal axis of plate 100. Tab 136 also functions to limit movement of first segment 102 in a direction transverse to longitudinal axis of plate 100 to prevent end 124 from dropping down beyond a desired position. This limited movement of first segment 100 prevents medial portion 122 of first segment 102 from lifting away from medial portion 142 beyond a desired position, so that ratchetings 150 are not overly separated and rendered less effective as described in more detail below. It is appreciated that other configurations of segments 102,104 are possible to hold apart segments 102,104 and to limit movement of the segments in a direction transverse to the longitudinal axis of the plate. For example, the longitudinal curvatures of first and second segments 102,104 can be slightly different to spring apart segments 102,104. For example, the radius of curvature of the lower surface of segment 102 may be different than the radius of curvature of the upper surface of segment 104.

[0087] At least a portion of lower surface 120 of first segment 102 and upper surface 138 of second segment 104 are preferably configured to interdigitate with one another to permit selected adjustment of the length of plate 100. For example, lower surface 120 and upper surface 138 may include a surface configuration, such as ratchetings 152, configured to cooperatively interdigitate to permit selected and sequential movement along the longitudinal axis of plate 100. The ratchetings are preferably biased to allow movement in one preferred direction along the longitudinal axis of the plate so as to allow shortening of the plate and resist lengthening of the plate.

[0088] FIGS. 9 and 10 show an embodiment of ratchetings having a configuration that is useful if no movement of first and second segments 102, 104 is desired after fastener 106 is tightened. A preferred angular relationship of the cross section of ratchetings 152a is a 45-45-90 degree triangular relationship. As shown in FIG. 9, in a first position, the peaks and valleys of ratchetings 152a are cooperatively mating. Ratchetings 152a permit for the fixed positioning of first and second segments 102,104 relative to one another to create a selected length of plate 100. As shown in FIG. 10, the peaks and valleys are separated to permit movement of the first and second segments in the directions of the arrows along the longitudinal axis of plate 100. In order for first and second segments 102,104 to move relative to one another, there must be sufficient freedom of movement for the segments to move apart in order to clear the height of the peaks of ratchetings 152a. Accordingly, in a preferred embodiment fastener 106 is configured to have at least one position that permits movement of the first and

second segments along the longitudinal axis of plate 100 as well as along an axis transverse to the longitudinal axis of plate 100 such that ratchetings 152 can move apart. Fastener 106 can be tightened to a second position to resist or prevent movement of segments 102,104 relative to one another. For example, movement of segments 102,104 can be resisted in a direction along at least a portion of the longitudinal axis of plate 100.

[0089] FIGS. 11 and 12 show another preferred embodiment of ratchetings 152b having a forward-facing configuration for permitting movement in a single direction. The configuration of ratchetings 152b is useful when movement of first and second segments 102,104 is desired to permit further shortening of the plate. A preferred angular relationship of the triangular cross section of ratchetings 152b is a 30-60-90 degree triangular relationship. As shown in FIG. 12, due to the forward facing angle of ratchetings 152b, sliding movement of first and second segments 102,104 in the direction, as indicated by the arrow, along the longitudinal axis of plate 100 is facilitated by the ramped surface 154. In contrast, sliding movement in the opposite direction is restricted by vertical wall 156. Movement of segments 102,104 is limited to a single direction with ratchetings 152a and by limiting the separation of segments 102,104 along an axis transverse to the longitudinal axis of plate 100 with fastener 106 or 106'.

[0090] In a preferred embodiment, fastener 106 or 106' is configured to have at least one position that permits movement of first and second segments 102, 104 in both directions along the longitudinal axis of plate 100 as well as along an axis transverse to the longitudinal axis of plate 100 such that ratchetings 152b can move apart. For example, in a first position fastener 106 can be less than fully tightened to plate 100 as desired by the surgeon to permit movement of first and second segments relative to each other. Fastener 106' can further have a second position that permits movement of segments 102,104 relative to one another only in a single direction along the longitudinal axis of plate 100 and limits movement along an axis transverse to the longitudinal axis of plate 100. Therefore, plate 100 can be shortened if the distance between the two adjacent vertebral bodies decreases, even after plate 100 is installed, so that the vertebral bodies are not held apart by plate 100, to prevent the occurrence of pseudoarthrosis. One of the benefits of a forward-facing configuration of ratchetings 152b is the ability to store and impart a compressive load across the fusion site. The compressive load stored may be applied by the surgeon and/or compressive loads that occur randomly with neck motion during the healing phase. First and second segments 102,104 may be pre-adjusted to correspond to the appropriate size and spacing of the adjacent vertebral bodies to be fused prior to placement of plate 100 against the vertebral bodies by moving first and second segments 102, 104 relative to one another while fastener 106 is only partially tightened for the purpose of appropriately adjusting the length of the plate. Then, fastener 106 may be further tightened to secure first and second segments 102, 104 in the desired position.

[0091] In a preferred embodiment, plate 100 includes at least one bone screw lock 172 adapted to lock to plate 100 at least two bone screws inserted in bone screw receiving holes 126. Bone screw locks 172 are coupled to plate 100 and may be removable or may be non-detachably attached to

plate 100. Bone screw locks 172 may be coupled to plate 100 prior to the insertion of the bone screws into bone screw receiving holes 126. Alternatively, the bone screw locks may be coupled to the plate after the insertion of the bone screws into the bone screw receiving holes.

[0092] As shown in FIGS. 1-4, 14, and 15, by way of example only and not limitation, bone screw lock 172 may have a tool engagement portion 174 adapted to cooperatively engage an instrument used for coupling bone screw lock 172 to plate 100 and at least one cutout 176. Each cutout 176 is oriented so as to permit introduction of a bone screw into an adjacent bone screw receiving hole when bone screw lock 172 is coupled to plate 100 and in the appropriate orientation. It is appreciated that other configurations of the bone screw lock are possible so as to permit introduction of a bone screw into a bone screw receiving hole adjacent to the bone screw lock without interference from the bone screw lock.

[0093] Plate 100 may have an opening 178 for receiving at least a portion of locking element 172 and may, but need not, include a recess 180 for receiving at least a portion of locking element 172 therein. Bone screw lock 172 may have a stem 182 configured to fit at least in part within opening 178 in plate 100. Stem 182 and opening 178 may be threaded to threadably engage bone screw lock 172 to plate 100. Alternatively, at least a portion of the interior perimeter of recess 180 and at least a portion of the perimeter of the bone screw lock may be threaded to threadably engage the bone screw lock to the plate.

[0094] In a preferred embodiment, bone screw locks 172 are configured to move from an initial position, that permits the insertion of bone screws into the bone screw receiving holes, to a final position that is adapted to extend over at least a portion of at least two of the bone screws to retain the bone screws to the plate. The bone screw lock may be adapted to be rotated from the initial position to the final position, and preferably, less than a full rotation of the bone screw lock rotates the bone screw lock from the initial position to the final position. In a preferred embodiment, the bone screw lock in the final position covers at least a portion of at least two of the bone screw receiving holes.

[0095] In another preferred embodiment, at least a portion of the bone screw lock slides from the initial position to the final position. The bone screw lock can slide over at least a portion of at least two of the bone screw receiving holes and/or slide over at least a portion of at least two bone screws in the bone screw receiving holes.

[0096] The bone screw lock may be in the form of a screw, a rivet, a cap, a cover, or have any other configuration suitable for its intended purpose. The bone screw lock may have a head that is at least in part circular.

[0097] The plates of the present invention may be utilized with any lock suitable for locking a plurality of bone screws to an anterior cervical plate known to those of ordinary skill in the art, including but not limited to, the bone screw locks taught by Michelson in U.S. Pat. No. 6,193,721 (the '721 patent), incorporated by reference herein.

[0098] With appropriate embodiments of the plates described herein, the surgeon may induce a desired amount of "preload," or compressive force across the fusion site after plate attachment by moving first and second segments

102, 104 toward one another to shorten the length of plate 100 as desired. Inducing a preload enhances fusion by maintaining a compressive force between adjacent vertebral bodies and reducing the chance that gaps might develop as new living bone replaces the dead bone during the fusion process.

[0099] FIGS. 13-15 show a preferred embodiment of instrumentation 200 for compressing and locking plate 100. Instrumentation 200 has a handle 202 with a pair of tongs 204, 206 in moveable relationship to each. Tongs 204, 206 are configured to cooperatively engage ends 124, 144 of first and second segments, 102, 104, respectively. Instrumentation 200 may be used to hold and position plate 100 in a desired position at the fusion site during at least a portion of the procedure for installing plate 100. Any instrument capable of engaging the plate so as to serve the intended purpose would be within the scope of the instrumentation and method of the present invention. As an example only, methods and instrumentation for installing plates to the cervical spine, including a pilot hole forming punch to create bone screw receiving holes in the vertebral bodies coaxially aligned with the bone screw receiving holes with the plate, are taught and described by Michelson in the '721 patent, incorporated by reference herein. After segments 102, 104 have been attached to the adjacent vertebral bodies with an appropriate fastening element, such as bone screws, instrument 200 can be used to move segments 102, 104 toward one another to shorten the length of plate 100 and create a compressive load across the disc space. After the desired length of plate 100 is achieved, an instrument 208 having a head 210 configured to cooperatively engage fastener 106 is used to tighten fastener 106 to secure first and second segments 102, 104 in a desired position. When in a secured position, segments 102, 104 may maintain a compressive load across the disc space if desired. Head 210 of instrument 208 may have a hex-shaped configuration.

[0100] FIGS. 16-22 show another preferred embodiment of a cervical plate 300 having an internal compression mechanism in accordance with the present invention. Plate 300 is similar to plate 100 except that fastener receiving opening 330 and fastener 306 function as part of a mechanism to move first and second segments 302, 304 relative to one another to change the length of plate 300 to generate a compressive load across the disc space between two adjacent vertebral bodies to be fused. Fastener receiving opening 330 includes instrument pin receiving recesses 362a and 362b for cooperating with the pin of an instrument 400 (described below) for moving first and second segments 302, 304 relative to one another. In addition, instead of a tab 136, plate 300 has pins 358 and tracks 360 to maintain first and second segments 302, 304 aligned along the longitudinal axis of plate 300. Bone screw lock 372 is adapted to lock to plate 300 at least two bone screws inserted in bone screw receiving holes 326.

[0101] As shown in FIGS. 20-22, first segment 302 preferably has two pins 358 depending therefrom for engagement in corresponding tracks 360 in second segment 304. Pins 358 slideably engage tracks 360, respectively, and travel therein when first and second segments 302, 304 are moved relative to one another. Tracks 360 are staggered along the length of medial portion 342 and pins 358 are staggered along the length of medial portion 322 to maintain first and second segments 302, 304 aligned along the lon-

itudinal axis of plate 300. It is appreciated that any plate configuration to achieve the intended purpose of maintaining first and second segments 302, 304 aligned along the longitudinal axis of the plate would be within the scope of the present invention.

[0102] FIGS. 23-26 show a preferred embodiment of an instrumentation 400 used for compressing and locking plate 300. Instrumentation 400 has a working end 402 configured to cooperatively engage fastener receiving opening 330 and fastener 306. After segments 302, 304 have been attached to the adjacent vertebral bodies with an appropriate fastening element, such as bone screws, instrument 400 can be used to move segments 302, 304 toward one another to shorten the length of plate 300, create a compressive load across the disc space, and concurrently tighten fastener 306 (if desired) to secure first and second segments 302, 304 in a preferred position. Working end 402 of instrument 400 preferably has a driver portion 404 configured to cooperatively engage driver receiving opening 364 in fastener 306. Driver portion 404 is preferably hex-shaped. Working end 402 preferably has a pin 406 extending therefrom and displaced from driver portion 404 to engage one of pin receiving recesses 362a and 362b, respectively, when driver portion 404 is engaged with driver receiving opening 364 in fastener 306. With driver portion 404 engaging fastener 306 and pin 406 inserted in pin receiving recess 362b as shown in FIG. 25, instrument 400 rotates fastener 306 in the direction of arrow A as shown in FIG. 26 to move first segment 302 toward second segment 304 in the direction of arrow B to reduce the length of plate 300 and can if desired concurrently tighten fastener 306. The configuration of plate 300 provides for an internal compression mechanism that can be operated by a driver instrument eliminating the need for an externally applied compression apparatus for shortening plate 300 and creating a compressive load.

[0103] FIGS. 27-28 show another preferred embodiment of a cervical plate 500 in accordance with the present invention. Plate 500 is similar to plate 100 except that first segment 502 is configured to receive at least a portion of second segment 504 therein in a tongue and groove configuration. As shown in FIG. 28, first segment 502 preferably has a C-shaped cross section and second segment 504 preferably has a T-shaped cross section. The configurations of segments 502, 504 in this embodiment of the present invention keep segments 502, 504 aligned along the longitudinal axis of plate 500 and limit movement of segments 502, 504 in a direction generally transverse to the longitudinal axis of plate 500. A person of ordinary skill in the art would appreciate that other configurations of cooperatively engaging first and second segments 502, 504 are possible without departing from the intended purpose within the broad scope of the present invention. Bone screw lock 572 is adapted to lock to plate 500 at least two bone screws inserted in bone screw receiving holes 526.

[0104] FIGS. 29-36 show another preferred embodiment of a cervical plate 600 in accordance with the present invention. Plate 600 is similar to plate 100 except that it is configured for use across two levels of the cervical spine. In addition to the elements of plate 100, plate 600 further includes an intermediate third segment 666 between first and second segments 602, 604. Third segment 666 has a first end 668 configured to cooperatively engage first segment 602. Third segment 666 has a second end 670 configured to

cooperatively engage second segment 604. Third segment 666 and first and second segments 602, 604 are articulated and can be moved to vary the spacing between the bone screw receiving holes of the plate segments as well as the overall length of the plate. Third segment 666 can be made of different lengths and/or configurations to vary the distance between first and second segments 602, 604 to further vary the spacing between the bone screw receiving holes and further vary the overall length of the plate.

[0105] In a preferred embodiment of the present invention, plate 600 could be provided to the health care facility in a set of segments. For example, a set or group of six segments could include a longer and a shorter one of first, second, and third segments 602, 604, 666. These segments could be assembled to cover a range of sizes. Additional intermediate segments 666 can be used to assemble a plate that covers additional levels of the spine and preferably the spacing between plate segments would be adjustable.

[0106] First end 668 of third segment 666 has similar features to second segment 604 including a fastener receiving recess 648, bone screw receiving holes 626, ratcheting 652 on at least a portion of its upper surface 638, and a tab 636. Second end 670 of third segment 666 has similar features to first segment 602 including a ratcheting 652 on at least a portion of its lower surface 620 and a tab receiving recess 634. A first fastener 606 couples together first segment 602 to first end 668 of third segment 666. A second fastener couples together second segment 604 to second end 670 of third segment 666. Additional segments 666 may be added for use across more than two levels of the spine. Segments 666 are configured to be coupled together with first end 668 of one segment 666 to second end 670 of another segment 666. Bone screw lock 672 is adapted to lock to plate 600 at least two bone screws inserted in bone screw receiving holes 626.

[0107] FIGS. 37-39 show a preferred embodiment of instrumentation 700 for compressing and locking plate 600. Instrumentation 700 has a handle 702 with a pair of tongs 704, 706 in moveable relationship to each. Tongs 704, 706 are configured to cooperatively engage ends 624, 644 of first and second segments, 602, 604, respectively, to shorten the overall length of the plate and to apply a desired compressive load across multiple levels of the spine. Instrumentation 700 may be used to position plate 600 in a desired position at the fusion site during at least a portion of the procedure for installing plate 600. An instrument may be used for holding the plate such as the instrumentation disclosed in the '721 patent incorporated by reference above. Instrument 700 can be used to move segments 602, 604 toward one another and toward third segment 666 to shorten the length of plate 600 and create a compressive load across the respective disc spaces.

[0108] As shown in FIG. 38, an alternative embodiment of instrument 700' may be used to move first or second segment 602, 604 toward third segment 666 so that a compressive load may be applied to one disc space at a time. Instrument 700' has a tong 704' similar to tong 704 for engaging one of ends 624, 644 of first and second segments, and forked tong 707 for engaging the third segment as shown in FIG. 38.

[0109] After the desired length of plate 600 is achieved, an instrument 708 having a head 710 configured to coopera-

tively engage fastener 606 is used to tighten fastener 606 to secure first, second, and third segments 602, 604, 666 in a desired position.

[0110] FIG. 40 shows another preferred embodiment of a cervical plate 800 in accordance with the present invention. Plate 800 is similar to plate 600 except that first segment 802 is configured to receive at least a portion of the first end 868 of third segment 866 therein in a tongue and groove configuration and second end 870 of third segment 866 is configured to receive at least a portion of second segment 804 therein, in a tongue and groove configuration. A person of ordinary skill in the art would appreciate that other configurations of cooperatively engaging first and second segments 802, 804 are possible without departing from the intended purpose within the broad scope of the present invention. Bone screw lock 872 is adapted to lock to plate 800 at least two bone screws inserted in bone screw receiving holes 826.

[0111] The plate of the present invention preferably includes at least one bone screw lock adapted to lock to the plate at least two bone screws inserted into the bone screw receiving holes, respectively. The plate of the present invention may include more than one bone screw lock, each lock being adapted to lock to the plate at least two bone screws inserted into the bone screw receiving holes, respectively.

[0112] FIG. 41 shows a cervical plate 900 with locking elements 902 in accordance with another preferred embodiment of the present invention. Locking elements 902 are adapted to lock at least two bone screws installed in each of bone screw receiving holes 916, respectively. Locking element 902 is in moveable relationship to plate 900 so that locking element 902 can be pre-installed to plate 900 prior to the insertion of bone screws into bone screw receiving holes 916. During installation of the bone screws, locking element 902 can be slid to one side of the plate as shown in the top portion of the plate in FIG. 41 to allow for insertion of a first bone screw into a first bone screw receiving hole 916 on the opposite side of plate 900. Locking element 902 is then moved to the opposite side of plate 900 to permit insertion of a second bone screw into the second bone screw receiving hole 916. Locking element 902 is then moved to cover at least a portion of both first and second bone screws and can be locked in place by a screw 917 as shown in the middle and bottom portions of plate 900 in FIG. 41.

[0113] FIGS. 42 and 43 show a cervical plate 1000 with locking elements 1002 in accordance with another preferred embodiment of the present invention. Locking elements 1002 are installed to cover at least a portion of two bone screw receiving holes 1016. In this embodiment, the bone screws are installed in bone screw receiving holes 1016 and locking element 1002 is placed over at least a portion of two bone screws to lock the bone screws. Locking element 1002 can be held in place with a screw 1017 that passes at least in part through opening 1003 in locking element 1002 and engages opening 1005 in plate 1000 to lock two bone screws 1048 to plate 1000 as shown in FIG. 43. Bone screws 1048 preferably have a leading end configured for insertion into the cervical spine and a head 1049 opposite the leading end that may be configured to contact locking element 1002. By way of example only, bone screws 1048 may be configured to be in a fixed relationship to plate 1000 such as shown in FIG. 43.

[0114] FIG. 44 is a fragmentary cross sectional view of another preferred embodiment of a locking element 1002' and bone screws 1048'. Locking element 1002' has a bottom surface adapted to cooperate with a rounded portion of head 1049' of bone screws 1048' and is adapted to hold bone screws 1048' in an angular relationship to plate 1000'. Examples of preferred fixed-angled locking elements are taught by Michelson in U.S. Pat. No. 6,139,550 (the '550 patent) entitled "Skeletal Plating System," the disclosure of which is hereby incorporated by reference herein. Locking element 1002' may also permit movement of bone screw 1048' relative to plate 1000'. Locking element 1002' may also be adapted to adjustably lock bone screws 1048' in a variable angle relationship relative to plate 1000'. Examples of preferred variable-angled locking elements are taught by Michelson in the '550 patent. The rounded portion of head 1049' permits bone screws 1048' to be in a moveable relationship, such as for example in a variable angular relationship to plate 1000'. Other configurations are possible for the intended purpose and are within the broad scope of the present invention.

[0115] Various methods for using and installing the plates of the present invention are disclosed in the '550 and '721 patents to Michelson identified above, incorporated by reference herein.

[0116] FIG. 45 shows a plate 1100 and a locking element 1180 adapted to lock at least two bone screws and a fastener 1134 in accordance with the present invention. Preferably, locking element 1180 is configured to be preinstalled to plate 1100 prior to insertion of the bone screws in bone screw receiving holes 1116 and attachment of fastener 1134 to plate 1100. Locking element 1180 has a first position that permits insertion of bone screws in respective bone screw receiving holes 1116 and installation and/or movement of fastener 1134. Locking element 1180 has a second position that covers at least a portion of at least two bone screw receiving holes 1116 and fastener 1134 to lock at least two bone screws and fastener 1134 to plate 1100. Locking element 1180 may preferably be configured to rotatably and/or slideably cover at least a portion of two bone screws in bone screw receiving holes 1116 and at least a portion of fastener 1134.

[0117] FIG. 46 shows another preferred embodiment of a plate 1200 and locking element 1280 adapted to lock at least two bone screws and a fastener 1234 in accordance with the present invention. Locking element 1280 is configured to be installed to plate 1200 after insertion of bone screws in bone screw receiving holes 1216 and attachment of fastener 1234 to plate 1200. Locking element 1280 is configured to cover at least a portion of at least two bone screw receiving holes 1216 and fastener 1234 to lock at least two bone screws and at least a portion of fastener 1234 to plate 1200. Locking element 1280 is preferably attached to plate 1200 by a screw 1217 or by any other means suitable for the intended purpose.

[0118] The plates of present invention may include a bone screw system that allows the vertebrae to move toward an interposed bone graft, and each other if necessary, instead of keeping the vertebrae apart during the occurrence of the resorption phase of the creeping substitution process. For example, the '550 patent discloses three types of screw-plate-lock systems, which are themselves combinable with

one another, as follows: (1) Passive Dynamic; (2) Self-Compressing; and (3) Active Dynamic and are incorporated by reference herein. The plate of the present invention requires (1) at least one fastener detachably attached to the plate to permit assembly and disassembly of two or more plate segments as desired; and (2) at least one lock that is adapted to lock at least two bone screws so as to prevent the screws from backing out from the bone screw receiving holes of the plate. Plates similar to that of the present invention described herein having non-detachable fasteners to prevent non-destructive complete uncoupling of the plate segments from one another are being pursued in related applications. Plates similar to that of the present invention described herein having single-lock mechanisms adapted to lock only one bone screw as described in the '550 patent and the '721 patent are being pursued in related applications.

[0119] It is appreciated that for any of the embodiments of the plates described herein can be made of, treated, coated, combined with, comprised of, or used with any source of osteogenesis, fusion promoting substances, bone growth promoting materials, bone, bone derived substances or products, demineralized bone matrix, mineralizing proteins, ossifying proteins, bone morphogenetic proteins, hydroxyapatite, genes coding for the production of bone, substances other than bone, and bone including, but not limited to, cortical bone. The plates, screws, fasteners, and/or screw locks may also be combined with material and/or substance for inhibiting scar formation. The plates, screws, fasteners, and/or screw locks may be combined with an antimicrobial material and/or surface treated or coated to be antibacterial and/or antimicrobial, such as for example, by a silver coating. At least a portion of the bottom surface of the plates can preferably have a porous, and/or textured and/or roughened surface and may be coated with, impregnated with, or comprise of fusion promoting substances (such as bone morphogenetic proteins) so as to encourage the growth of bone along the underside of the plate from bone portion to bone portion. The textured bottom surface also provides a medium for retaining fusion promoting substances with which the bottom surface layer can be impregnated prior to installation. The bottom surface of the plate may be given the desired porous textured form by rough blasting or any other conventional technology, such as etching, plasma spraying, sintering, and casting for example. If porous so as to promote bone ingrowth, the bottom surface is formed to have a porosity or pore size in the order of 50-500 microns, and preferably 100-300 microns. Bone growth promoting substances with which the porous, textured bottom surface can be impregnated include, but are not limited to, bone morphogenetic proteins, hydroxyapatite, or hydroxyapatite tricalcium phosphate. The plate, screws, fasteners, and/or bone screw locks may include at least in part a resorbable and/or bioresorbable material which can further be impregnated with a bone growth material so that as the resorbable and/or bioresorbable material is resorbed by the body of the patient, the bone growth material is released, thus acting as a time release mechanism. The bioresorbable material may be, for example, at least in part bone. The plate of the present invention may be used in combination with a spinal fixation implant such as any object, regardless of material, that can be inserted into any portion of the spine, such as but not limited to interbody spinal implants, interbody spinal fusion implants, structural bone grafts, mesh, cages, spacers, staples, bone screws, plates, rods, tethers of synthetic cords

or wires, or other spinal fixation hardware. The interbody spinal fusion implants may be at least in part bone, for example only, an allograft interbody bone graft. Alternatively, the spinal interbody spinal fusion implant may be at least in part artificial. At least one of the plate, screws, fasteners, and/or bone screw locks may be, if so desired, electrified for purposes of stimulating bone growth and contributing to bone fusion.

[0120] Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A plate adapted to be applied to the anterior human cervical spine for contacting the anterior aspects of at least two cervical vertebral bodies to be fused together, said plate comprising:

at least a first plate segment adapted to be attached to one of the adjacent vertebral bodies to be fused and at least a second plate segment adapted to be attached to another one of the adjacent vertebral bodies to be fused, said at least first and second plate segments adapted to be connected to one another and at least in part overlapped to form said plate, said at least first and second plate segments being in a moveable relationship to one another along a longitudinal axis of said plate, each of said at least first and second plate segments including:

a lower surface adapted to contact at least one of the cervical vertebral bodies and an upper surface opposite said lower surface, said lower surface being concave at least in part along at least a portion of the longitudinal axis of said plate;

at least one bone screw receiving hole extending from said upper surface through said lower surface, each of said bone screw receiving holes adapted to overlie one of the cervical vertebral bodies and being adapted to receive at least one bone screw for engaging the cervical vertebral body to attach said plate to the cervical spine;

at least one fastener adapted to couple together said first and second plate segments, said fastener being detachably attached to at least one of said first and second plate segments so as to permit assembly of said first and second plate segments by the surgeon and complete uncoupling of said first and second plate segments relative to one another, said fastener having a first position adapted to facilitate movement of said first and second plate segments in a direction toward one another along the longitudinal axis of said plate and to resist movement of said first and said second plate segments in a direction away from one another along the longitudinal axis of said plate; and

at least one bone screw lock adapted to lock to said plate at least two bone screws inserted in said bone screw receiving holes, respectively.

2. The plate of claim 1, wherein said first and second plate segments move in only a single direction toward one another along the longitudinal axis of said plate when said fastener is in said first position.

3. The plate of claim 1, wherein said fastener has a second position adapted to limit movement of said first and second plate segments relative to one another along the longitudinal axis of said plate.

4. The plate of claim 1, wherein said fastener is configured so as to be able to completely restrict movement of said first and second plate segments relative to one another along at least a mid-longitudinal axis of said plate.

5. The plate of claim 1, wherein said fastener passes through at least a portion of said first and second plate segments.

6. The plate of claim 1, wherein said fastener is configured to limit separation of said first and second plate segments relative to one another.

7. The plate of claim 1, wherein said fastener is configured to be tightened to only one of said at least first and second plate segments so as to permit movement of said first and second plate segments relative to one another.

8. The plate of claim 1, wherein said fastener is a part of a mechanism for moving said first and second plate segments relative to one another along a mid-longitudinal axis of said plate.

9. The plate of claim 1, in combination with an instrument configured to cooperatively engage said fastener and at least a portion of at least one of said first and second plate segments so as upon movement of said fastener with said instrument said first and second plate segments move relative to one another along a mid-longitudinal axis of said plate.

10. The plate of claim 9, wherein said fastener is configured to be rotated at least in part by said instrument.

11. The plate of claim 1, wherein said fastener is a screw.

12. The plate of claim 1, where said fastener is at least in part threaded.

13. The plate of claim 1, wherein said fastener has a head.

14. The plate of claim 12, wherein said fastener has a shaft.

15. The plate of claim 1, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to move toward one another in response to movement of the adjacent cervical vertebral bodies toward each other.

16. The plate of claim 1, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to move the adjacent cervical vertebral bodies toward each other in response to movement of said first and second plate segments moving toward each other.

17. The plate of claim 3, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to maintain a compressive load across a disc space between the adjacent cervical vertebral bodies when said fastener is in said second position.

18. The plate of claim 1, wherein at least a portion of said upper surface of said second plate segment is convex at least in part along at least a portion of the longitudinal axis of said plate.

19. The plate of claim 18, wherein said concave lower surface of said first plate segment has a radius of curvature that is different than the radius of curvature of said convex upper surface of said second plate segment.

20. The plate of claim 1, wherein said at least first and second plate segments are configured to cooperate so as to maintain said first and second plate segments generally aligned along the longitudinal axis of said plate.

21. The plate of claim 1, wherein said at least first and second plate segments are configured to cooperate so as to limit movement of said first and second plate segments in a direction generally transverse to the longitudinal axis of said plate.

22. The plate of claim 1, wherein at least a portion of said lower surface of said first plate segment is configured to cooperatively engage at least a portion of said upper surface of said second plate segment.

23. The plate of claim 1, wherein said at least a portion of said lower surface of said first plate segment is configured to interdigitate with at least a portion of said upper surface of said second plate segment.

24. The plate of claim 23, wherein said at least a portion of said lower surface of said first plate segment and said at least a portion of the upper surface of said second plate segment include ratchetings.

25. The plate of claim 24, wherein said ratchetings are configured to permit movement of said first and second plate segments toward one another in a first direction along a mid-longitudinal axis of said plate and to restrict movement in a direction opposite to said first direction.

26. The plate of claim 1, wherein at least one of said first and second plate segments is selected from a group of plate segments of various lengths.

27. The plate of claim 1, wherein at least one of said first and second plate segments is selected from a group of plate segments of various configurations.

28. The plate of claim 1, further comprising at least a third plate segment adapted to be connected to at least one of said first and second plate segments to form said plate.

29. The plate of claim 28, wherein said third plate segment is an intermediate plate segment configured to be coupled between at least two plate segments.

30. The plate of claim 26, wherein at least one of said first, second, and third plate segments is selected from a group of plate segments of various lengths.

31. The plate of claim 26, wherein at least one of said first, second, and third plate segments is selected from a group of plate segments of various configurations.

32. The plate of claim 31, wherein said first, second, and third plate segments are selected from a group including end segments and intermediary segments.

33. The plate of claim 32, wherein each of said end segments is configured to connect to one of said end segments and said intermediary segments, and each of said intermediary segments is configured to connect to at least one of said end segments and said intermediary segments.

34. The plate of claim 1, wherein said at least one bone screw lock is coupled to said plate.

35. The plate of claim 34, wherein said at least one bone screw lock is removably coupled to said plate.

36. The plate of claim 34, wherein said at least one bone screw lock is adapted to be coupled to said plate prior to the insertion of the bone screws into said bone screw receiving holes.

37. The plate of claim 1, wherein said at least one bone screw lock is configured to move from an initial position that permits the insertion of the bone screws into said bone screw receiving holes to a final position that is adapted to extend over at least a portion of at least two of the bone screws to retain the bone screws to said plate.

38. The plate of claim 37, wherein said at least one bone screw lock in the final position covers at least a portion of at least two of said bone screw receiving holes.

39. The plate of claim 37, wherein said at least one bone screw lock is adapted to be rotated from the initial position to the final position.

40. The plate of claim 39, wherein less than a full rotation of said at least one bone screw lock rotates said bone screw lock from the initial position to the final position.

41. The plate of claim 1, wherein at least a portion of said at least one bone screw lock slides from the initial position to the final position.

42. The plate of claim 41, wherein said at least one bone screw lock slides over at least a portion of at least two of said bone screw receiving holes.

43. The plate of claim 42, wherein said at least one bone screw lock slides over at least a portion of at least two bone screws in said bone screw receiving holes.

44. The plate of claim 1, wherein said at least one bone screw lock comprises at least one of a screw, a rivet, a cap, and a cover.

45. The plate of claim 1, wherein said at least one bone screw lock comprises a head that is at least in part circular.

46. The plate of claim 45, wherein said head has at least one cutout segment.

47. The plate of claim 1, wherein said at least one bone screw lock is adapted to lock to said plate said at least one fastener.

48. The plate of claim 47, wherein said at least one bone screw lock covers at least a portion of at least two of said bone screw receiving holes and at least a portion of said at least one fastener.

49. The plate of claim 47, wherein said at least one bone screw lock slides over at least a portion of at least two bone screws in said bone screw receiving holes and at least a portion of said at least one fastener.

50. The plate of claim 1, wherein at least one end of said plate is configured to cooperatively engage a compression tool for movement of at least one vertebral body toward another vertebral body during installation of said plate.

51. The plate of claim 1, wherein said concave part of said lower surface of said first and second plate segment is configured to conform to the anterior aspect of at least a portion of two cervical vertebral bodies.

52. The plate of claim 1, wherein at least a portion of said lower surface of said first and second plate segment is at least in part concave transverse to the longitudinal axis of the plate.

53. The plate of claim 1, wherein at least a portion of said lower surface of said first and second plate segments is roughened to promote the growth of bone along said lower surface.

54. The plate of claim 1, wherein at least a portion of said lower surface of said first and second plate segments comprises a bone ingrowth surface.

55. The plate of claim 1, wherein at least one of said bone screw receiving holes is configured to form an interference fit with at least a portion of the trailing end of a properly dimensioned bone screw to be received therein.

56. The plate of claim 1, wherein at least one of said bone screw receiving holes is configured to hold a bone screw in fixed relationship to said plate.

57. The plate of claim 1, wherein at least one of said bone screw receiving holes is configured to allow a bone screw to be in a moveable relationship to said plate.

58. The plate of claim 1, wherein at least one of said bone screw receiving holes is configured to allow a bone screw to be in a variable angular relationship to said plate.

59. The plate of claim 1, wherein at least two of said bone screw receiving holes are oriented in said plate to overlie the anterior aspect of a single cervical vertebral body adjacent a disc space to be fused.

60. The plate of claim 1, wherein at least a first pair of said bone screw receiving holes are oriented in said plate to overlie the anterior aspect of a first cervical vertebral body adjacent a disc space to be fused and at least a second pair of said bone screw receiving holes are oriented in said plate to overlie the anterior aspect of a second cervical vertebral body adjacent the disc space to be fused.

61. The plate of claim 1, in combination with an interbody spinal fusion implant.

62. The plate of claim 61, wherein said implant comprises at least in part bone.

63. The plate of claim 61, wherein said implant is an allograft interbody bone graft implant.

64. The plate of claim 61, wherein said implant is an artificial implant.

65. The plate of claim 1, in combination with a fusion promoting substance.

66. The plate of claim 65, wherein said fusion promoting substance is at least in part other than bone.

67. The plate of claim 65, wherein said fusion promoting substance is at least in part bone.

68. The plate of claim 65, wherein said fusion promoting substance is hydroxyapatite.

69. The plate of claim 65, wherein said fusion promoting substance comprises bone morphogenetic protein.

70. The plate of claim 65, wherein said fusion promoting substance comprises genes coding for the production of bone.

71. The plate of claim 1, further comprising bone screws for engaging said plate to the cervical spine, wherein at least a portion of one of said plate, said at least one bone screw lock, and said bone screws is a bioresorbable material.

72. The plate of claim 71, wherein said bioresorbable material is at least in part bone.

73. The plate of claim 1, in combination with a substance for inhibiting scar formation.

74. The plate of claim 1, in combination with an antimicrobial material.

75. The plate of claim 1, wherein said plate is treated with an antimicrobial material.

76. The plate of claim 1, further in combination with at least one spinal fixation implant.

77. The plate of claim 1, further comprising at least one bone screw having a leading end for insertion into the cervical spine and a head opposite said leading end, said at least one bone screw lock adapted to contact said head.

78. The plate of claim 77, wherein said at least one bone screw is configured to be in fixed relationship to said plate.

79. The plate of claim 77, wherein said at least one bone screw is configured to be in a moveable relationship to said plate.

80. The plate of claim 77, wherein at least one bone screw is configured to be in a variable angular relationship to said plate.

81. The plate of claim 77, wherein at least one of said bone screw receiving holes has a reduced dimension proximate said lower surface of said plate to form a seat, said seat having a substantially planar surface adapted to contact a lower surface of one of said bone screws.

82. A method for stabilizing at least two adjacent vertebral bodies in the cervical human spine, comprising the steps of:

providing a plate of appropriate length adapted to overlap at least a portion of two adjacent cervical vertebral bodies anteriorly, said plate having at least a first plate segment adapted to be attached to one of the adjacent vertebral bodies to be fused and a second plate segment adapted to be attached to another one of the adjacent vertebral bodies to be fused, the first and second plate segments being in moveable relationship to one another along a longitudinal axis of the plate, the first and second plate segments fastened together by a fastener being detachably attached to at least one of the first and second plate segments so as to permit assembly of the plate segments by the surgeon and complete uncoupling of the first and second plate segments from one another;

inserting at least two bone screws through the first plate segment of the plate and into one of the vertebral bodies adjacent the disc space to be fused;

inserting at least two bone screws through the second plate segment and into the other of the vertebral bodies adjacent the disc space to be fused;

locking at least two of the bone screws with at least one bone screw lock adapted to lock to the plate at least two bone screws; and

permitting movement of the first and second plate segments attached to the adjacent vertebral bodies relative to one another.

83. The method of claim 82, wherein the permitting step includes the step of permitting movement of the first and second plate segments in only a single direction toward one another.

84. The method of claim 82, wherein the permitting step includes the step of allowing but not causing the movement of the adjacent vertebral bodies by movement of the first and second plate segments of the plate.

85. The method of claim 84, wherein the permitting step includes the first and second plate segments being free to move toward one another.

86. The method of claim 82, wherein the permitting step includes the step of allowing movement of the first and second plate segments of the plate in response to movement of the adjacent vertebral bodies.

87. The method of claim 82, wherein the permitting step includes the sub-step of limiting the movement of the first and second plate segments relative to one another to sequential increments along the longitudinal axis of the plate.

88. The method of claim 82, wherein the permitting step includes the step of causing movement of the adjacent vertebral bodies by moving the first and second plate segments relative to one another.

89. The method of claim 88, wherein the step of causing movement of the adjacent vertebral bodies includes the step of generating a compressive load across the disc space between the adjacent vertebral bodies.

90. The method of claim 89, wherein the permitting step includes the first and second plate segments being free to move toward one another.

91. The method of claim 88, wherein the step of causing movement of the adjacent vertebral bodies includes the step of storing a compressive load across the disc space between the adjacent vertebral bodies.

92. The method of claim 91, wherein the permitting step includes the first and second plate segments being in fixed relationship to one another.

93. The method of claim 88, further comprising the steps of providing an instrument configured to cooperatively engage the fastener and at least a portion of at least one of the first and second plate segments, and utilizing the instrument to move the fastener and the first and second plate segments relative to one another along a mid-longitudinal axis of the plate.

94. The method of claim 93, wherein the utilizing step includes the sub-step of rotating the fastener at least in part with the instrument.

95. The method of claim 82, wherein the permitting step occurs prior to the locking step.

96. The method of claim 82, wherein said permitting step includes the sub-step of moving the first and second plate segments relative to one another after the step of inserting the bone screws.

97. The method of claim 82, wherein said permitting step includes the sub-step of moving the first and second plate segments relative to one another before the step of inserting the bone screws.

98. The method of claim 82, further comprising the step of applying a compressive load to the adjacent vertebral bodies.

99. The method of claim 82, wherein said permitting step includes the sub-step of applying a compressive load to the adjacent vertebral bodies.

100. The method of claim 82, wherein the permitting step includes moving the first and second plate segments from a first position to a second position.

101. The method of claim 82, further comprising the step of tightening the fastener from a first position to a second position to resist movement of the first and second plate segments relative to each other in at least one direction.

102. The method of claim 101, wherein the tightening step includes resisting movement of the first and second plate segments relative to one another when the fastener is in the second position.

103. The method of claim 101, wherein the tightening step includes permitting movement of the first and second plate segments relative to one another when the fastener is in the second position.

104. The method of claim 103, wherein the tightening step includes limiting the movement of the first and second plate segments relative to one another to one direction along the longitudinal axis of the plate.

105. The method of claim 103, wherein the tightening step includes limiting the movement of the first and second plate segments relative to one another to sequential increments along the longitudinal axis of the plate.

106. The method of claim 101, wherein said tightening step includes tightening said fastener to cause the fastener to tighten to the first plate segment while permitting movement of the first and second plate segments relative to one another.

107. The method of claim 82, further comprising the step of adjusting the overall length of the plate by moving the first and second plate segments relative to each other.

108. The method of claim 82, wherein the providing step includes selecting at least one of the first and second plate segments from a group of plate segments of various lengths.

109. The method of claim 82, wherein the providing step includes selecting at least one of the first and second plate segments from a group of plate segments of various configurations.

110. The method of claim 82, wherein the providing step includes providing a plate having at least a third plate segment.

111. The method of claim 110, wherein the providing step includes selecting at least one of the first, second, and third plate segments from a group of plate segments of various lengths.

112. The method of claim 110, wherein the providing step includes selecting at least one of the first, second, and third plate segments from a plurality of plate segments of various configurations.

113. The method of claim 82, further comprising the step of combining the plate with an interbody spinal fusion implant.

114. The method of claim 113, wherein the implant comprises at least in part bone.

115. The method of claim 113, wherein the implant is an allograft interbody bone graft implant.

116. The method of claim 113, wherein the implant is an artificial implant.

117. The method of claim 82, further comprising the step of combining the plate with a fusion promoting substance.

118. The method of claim 117, wherein the fusion promoting substance is at least in part other than bone.

119. The method of claim 117, wherein the fusion promoting substance is at least in part bone.

120. The method of claim 117, wherein the fusion promoting substance is hydroxyapatite.

121. The method of claim 117, wherein the fusion promoting substance comprises bone morphogenetic protein.

122. The method of claim 117, wherein the fusion promoting substance comprises genes coding for the production of bone.

123. The method of claim 82, wherein the providing step further comprises the step of providing bone screws for engaging the plate to the cervical spine, wherein at least a portion of one of the plate, the at least one bone screw lock, and the bone screws is a bioresorbable material.

124. The method of claim 123, wherein the bioresorbable material is at least in part bone.

125. The method of claim 82, further comprising the step of combining the plate with a substance for inhibiting scar formation.

126. The method of claim 82, further comprising the step of combining the plate with an antimicrobial material.

127. The method of claim 82, further comprising the step of treating the plate with an antimicrobial material.

128. A plate system, comprising:

a plate adapted to be applied to the anterior human cervical spine for contacting the anterior aspects of at least two cervical vertebral bodies to be fused, said plate comprising:

at least a first plate segment adapted to be attached to one of the adjacent vertebral bodies to be fused and at least a second plate segment adapted to be attached to another one of the adjacent vertebral bodies to be fused, said at least first and second plate segments adapted to be connected to one another and at least in part overlapped to form said plate, said at least first and second plate segments being in a moveable relationship to one another along a longitudinal axis of said plate, each of said at least first and second plate segments including:

a lower surface adapted to contact at least one of the cervical vertebral bodies and an upper surface opposite said lower surface, said lower surface being concave at least in part along at least a portion of the longitudinal axis of said plate;

at least one bone screw receiving hole extending from said upper surface through said lower surface, each of said bone screw receiving holes adapted to overlie one of the cervical vertebral bodies and being adapted to receive at least one bone screw for engaging the cervical vertebral body to attach said plate to the cervical spine;

at least one fastener adapted to couple together said first and second plate segments, said fastener being detachably attached to at least one of said first and second plate segments so as to permit assembly of said first and second plate segments by the surgeon and complete uncoupling of said first and second plate segments from one another, said fastener having a first position adapted to permit said first and second plate segments to move relative to one another along the longitudinal axis of said plate; and

at least one bone screw lock adapted to lock to said plate at least two bone screws inserted in said bone screw receiving holes, respectively; and

an instrument configured to cooperatively engage said fastener and at least a portion of at least one of said first and second plate segments so as upon movement of said fastener with said instrument said first and second plate segments move relative to one another along the longitudinal axis of said plate.

129. The plate system of claim 128, wherein said instrument includes a working end having at least a first portion configured to cooperatively engage said fastener and at least a second portion offset from said first portion configured to cooperatively engage at least a portion of at least one of said first and second plate segments.

130. The plate system of claim 129, wherein said instrument has a shaft terminating at said working end and having a longitudinal axis, said first portion of said working end being generally aligned with the longitudinal axis of said shaft, and said second portion of said working end being offset from the longitudinal axis of the shaft.

131. The plate system of claim 129, wherein said instrument is configured to rotate said fastener at least in part.

132. The plate system of claim 128, wherein the movement of said first and second plate segments relative to one another provides for movement of the adjacent cervical vertebral bodies toward one another.

133. The plate system of claim 128, wherein said first and second plate segments when attached to the adjacent vertebral bodies toward one another.

bral bodies, respectively, are adapted to move toward one another in response to movement of the adjacent cervical vertebral bodies toward each other.

134. The plate system of claim 128, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to move the adjacent cervical vertebral bodies toward each other.

135. The plate system of claim 128, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to maintain a compressive load across a disc space between the adjacent cervical vertebral bodies when said fastener is in a second position.

136. The plate system of claim 128, wherein at least a portion of said upper surface of said second plate segment is convex at least in part along at least a portion of the longitudinal axis of said plate.

137. The plate system of claim 136, wherein said concave lower surface of said first plate segment has a radius of curvature that is different than the radius of curvature of said convex upper surface of said second plate segment.

138. The plate system of claim 128, wherein said at least first and second plate segments are configured to cooperate so as to maintain said first and second plate segments generally aligned along the longitudinal axis of said plate.

139. The plate system of claim 128, wherein said at least first and second plate segments are configured to cooperate so as to limit movement of said first and second plate segments in a direction generally transverse to the longitudinal axis of said plate.

140. The plate system of claim 128, wherein at least a portion of said lower surface of said first plate segment is configured to cooperatively engage at least a portion of said upper surface of said second plate segment.

141. The plate system of claim 128, wherein said at least a portion of said lower surface of said first plate segment is configured to interdigitate with at least a portion of said upper surface of said second plate segment.

142. The plate system of claim 141, wherein said at least a portion of said lower surface of said first plate segment and said at least a portion of the upper surface said second plate segment include ratchettings.

143. The plate system of claim 142, wherein said ratchettings are configured to permit movement of said first and second plate segments in a first direction toward one another along a mid-longitudinal axis of said plate and to restrict movement in a direction opposite to said first direction.

144. The plate system of claim 128, wherein at least one of said first and second plate segments is selected from a group of plate segments of various lengths.

145. The plate system of claim 128, wherein at least one of said first and second plate segments is selected from a group of plate segments of various configurations.

146. The plate system of claim 128, further comprising at least a third plate segment adapted to be connected to at least one of said first and second plate segments to form said plate.

147. The plate system of claim 146, wherein said third plate segment is an intermediate plate segment configured to be coupled between at least two plate segments.

148. The plate system of claim 144, wherein at least one of said first, second, and third plate segments is selected from a group of plate segments of various lengths.

149. The plate system of claim 144, wherein at least one of said first, second, and third plate segments is selected from a group of plate segments of various configurations.

150. The plate system of claim 149, wherein said first, second, and third plate segments are selected from a group including end segments and intermediary segments.

151. The plate system of claim 150, wherein each of said end segments is configured to connect to one of said end segments and said intermediary segments, and each of said intermediary segments is configured to connect to at least one of said end segments and said intermediary segments.

152. The plate system of claim 128, wherein said fastener has a second position adapted to restrict movement of said first and second plate segments relative to one another along at least one direction along the longitudinal axis of said plate.

153. The plate system of claim 128, wherein said fastener passes through at least a portion of said first and second plate segments.

154. The plate system of claim 128, wherein said fastener is a screw.

155. The plate system of claim 128, wherein said fastener is at least in part threaded.

156. The plate system of claim 128, wherein said fastener has a head.

157. The plate system of claim 156, wherein said fastener has a shaft.

158. The plate system of claim 128, wherein said at least one bone screw lock is coupled to said plate.

159. The plate system of claim 158, wherein said at least one bone screw lock is removably coupled to said plate.

160. The plate system of claim 158, wherein said at least one bone screw lock is adapted to be coupled to said plate prior to the insertion of the bone screws into said bone screw receiving holes.

161. The plate system of claim 128, wherein said at least one bone screw lock is configured to move from an initial position that permits the insertion of the bone screws into said bone screw receiving holes to a final position that is adapted to extend over at least a portion of at least two of the bone screws to retain the bone screws to said plate.

162. The plate system of claim 128, wherein said at least one bone screw lock in the final position covers at least a portion of at least two of said bone screw receiving holes.

163. The plate system of claim 128, wherein at least a portion of said at least one bone screw lock slides from the initial position to the final position.

164. The plate system of claim 163, wherein said at least one bone screw lock slides over at least a portion of at least two of said bone screw receiving holes.

165. The plate system of claim 164, wherein said at least one bone screw lock slides over at least a portion of at least two bone screws in said bone screw receiving holes.

166. The plate system of claim 128, wherein said at least one bone screw lock comprises at least one of a screw, a rivet, a cap, and a cover.

167. The plate system of claim 128, wherein said at least one bone screw lock is adapted to lock to said plate said at least one fastener.

168. The plate system of claim 167, wherein said at least one bone screw lock covers at least a portion of at least two of said bone screw receiving holes and at least a portion of said at least one fastener.

169. The plate system of claim 167, wherein said at least one bone screw lock slides over at least a portion of at least two bone screws in said bone screw receiving holes and at least a portion of said at least one fastener.

170. The plate system of claim 128, wherein at least a portion of said lower surface of said first and second plate segment is concave at least in part in a direction generally transverse to the longitudinal axis of said plate.

171. The plate system of claim 170, wherein at least a portion of said lower surface of said first and second plate segments is roughened to promote the growth of bone along said lower surface.

172. The plate system of claim 128, wherein at least a portion of said lower surface of said first and second plate segments comprises a bone ingrowth surface.

173. The plate system of claim 128, wherein at least one of said bone screw receiving holes is configured to form an interference fit with at least a portion of the trailing end of a properly dimensioned bone screw to be received therein.

174. The plate system of claim 128, wherein at least one of said bone screw receiving holes is configured to hold a bone screw in fixed relationship to said plate.

175. The plate system of claim 128, wherein at least one of said bone screw receiving holes is configured to allow a bone screw to be in a moveable relationship to said plate.

176. The plate system of claim 128, wherein at least one of said bone screw receiving holes is configured to allow a bone screw to be in a variable angular relationship to said plate.

177. The plate system of claim 128, wherein at least two of said bone screw receiving holes are oriented in said plate to overlie the anterior aspect of a single cervical vertebral body adjacent a disc space to be fused.

178. The plate system of claim 128, in combination with an interbody spinal fusion implant.

179. The plate system of claim 178, wherein said implant comprises at least in part bone.

180. The plate system of claim 178, wherein said implant is an allograft interbody bone graft implant.

181. The plate system of claim 178, wherein said implant is an artificial implant.

182. The plate system of claim 128, in combination with a fusion promoting substance.

183. The plate system of claim 182, wherein said fusion promoting substance is at least in part other than bone.

184. The plate system of claim 182, wherein said fusion promoting substance is at least in part bone.

185. The plate system of claim 182, wherein said fusion promoting substance is hydroxyapatite.

186. The plate system of claim 182, wherein said fusion promoting substance comprises bone morphogenetic protein.

187. The plate system of claim 182, wherein said fusion promoting substance comprises genes coding for the production of bone.

188. The plate system of claim 128, further comprising bone screws for engaging said plate to the cervical spine, wherein at least a portion of one of said plate, said at least one bone screw lock, and said bone screws is a bioresorbable material.

189. The plate system of claim 188, wherein said bioreversible material is at least in part bone.

190. The plate system of claim 128, in combination with a substance for inhibiting scar formation.

191. The plate system of claim 128, in combination with an antimicrobial material.

192. The plate system of claim 128, wherein said plate is treated with an antimicrobial material.

193. The plate system of claim 128, further in combination with at least one spinal fixation implant.

194. The plate system of claim 128, further comprising at least one bone screw having a leading end for insertion into the cervical spine and a head opposite said leading end, said at least one bone screw lock adapted to contact said head.

195. The plate system of claim 194, wherein said at least one bone screw is configured to be in fixed relationship to said plate.

196. The plate system of claim 194, wherein said at least one bone screw is configured to be in a moveable relationship to said plate.

197. The plate system of claim 194, wherein said at least one bone screw is configured to be in a variable angular relationship to said plate.

198. The plate system of claim 194, wherein at least one of said bone screw receiving holes has a reduced dimension proximate said lower surface of said plate to form a seat, said seat having a substantially planar surface adapted to contact a lower surface of one of said bone screws.

199. A plate adapted to be applied the anterior human cervical spine for contacting the anterior aspects of at least two cervical vertebral bodies to be fused together, said plate comprising:

- at least a first plate segment adapted to be attached to one of the adjacent vertebral bodies to be fused and at least a second plate segment adapted to be attached to another one of the adjacent vertebral bodies to be fused, said at least first and second plate segments adapted to be connected to one another and at least in part overlapped to form said plate, said at least first and second plate segments being in a moveable relationship to one another along a longitudinal axis of said plate, each of said at least first and second plate segments including:
- a lower surface adapted to contact at least one of the cervical vertebral bodies and an upper surface opposite said lower surface, said lower surface being concave at least in part along at least a portion of the longitudinal axis of said plate;
- at least one bone screw receiving hole extending from said upper surface through said lower surface, each of said bone screw receiving holes adapted to overlie one of the cervical vertebral bodies and being adapted to receive at least one bone screw for engaging the cervical vertebral body to attach said plate to the cervical spine;
- at least one fastener adapted to couple together said first and second plate segments, said fastener being detachably attached to at least one of said first and second plate segments so as to permit assembly of said first and second plate segments by the surgeon and complete uncoupling of said first and second plate segments from one another, said fastener having a first position adapted to permit said first and second plate segments to move relative to one another along the longitudinal axis of said plate; and
- at least one bone screw lock adapted to lock to said plate at least two bone screws inserted in said bone screw receiving holes, respectively.

200. The plate of claim 199, wherein said fastener has a second position adapted to limit movement of said first and second plate segments relative to one another along the longitudinal axis of said plate.

201. The plate of claim 199, wherein said fastener is configured so as to be able to completely restrict movement of said first and second plate segments relative to one another along at least the longitudinal axis of said plate.

202. The plate of claim 199, wherein said fastener passes through at least a portion of said first and second plate segments.

203. The plate of claim 199, wherein said fastener is configured to limit separation of said first and second plate segments relative to one another.

204. The plate of claim 199, wherein said fastener is configured to be tightened to only one of said at least first and second plate segments so as to permit movement of said first and second plate segments relative to one another.

205. The plate of claim 199, wherein said fastener is a part of a mechanism for moving said first and second plate segments relative to one another along a mid-longitudinal axis of said plate.

206. The plate of claim 199, wherein said fastener is a screw.

207. The plate of claim 199, where said fastener is at least in part threaded.

208. The plate of claim 199, wherein said fastener has a head.

209. The plate of claim 199, wherein said fastener has a shaft.

210. The plate of claim 199, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to move toward one another in response to movement of the adjacent cervical vertebral bodies toward each other.

211. The plate of claim 199, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to move the adjacent cervical vertebral bodies toward each other in response to movement of said first and second plate segments moving toward each other.

212. The plate of claim 200, wherein said first and second plate segments when attached to the adjacent vertebral bodies, respectively, are adapted to maintain a compressive load across a disc space between the adjacent cervical vertebral bodies when said fastener is in said second position.

213. The plate of claim 199, wherein said at least first and second plate segments are configured to cooperate so as to limit movement of said first and second plate segments in a direction generally transverse to the longitudinal axis of said plate.

214. The plate of claim 199, wherein said at least a portion of said lower surface of said first plate segment is configured to interdigitate with at least a portion of said upper surface of said second plate segment.

215. The plate of claim 214, wherein said at least a portion of said lower surface of said first plate segment and said at least a portion of the upper surface said second plate segment include ratcheting.

216. The plate of claim 215, wherein said ratcheting are configured to permit movement of said first and second plate segments toward one another in a first direction along a mid-longitudinal axis of said plate and to restrict movement in a direction opposite to said first direction.

217. The plate of claim 199, further comprising at least a third plate segment adapted to be connected to at least one of said first and second plate segments to form said plate.

218. The plate of claim 217, wherein said third plate segment is an intermediate plate segment configured to be coupled between at least two plate segments.

219. The plate of claim 199, wherein said at least one bone screw lock is coupled to said plate.

220. The plate of claim 199, wherein said at least one bone screw lock is removably coupled to said plate.

221. The plate of claim 199, wherein said at least one bone screw lock is configured to move from an initial position that permits the insertion of the bone screws into said bone screw receiving holes to a final position that is adapted to extend over at least a portion of at least two of the bone screws to retain the bone screws to said plate.

222. The plate of claim 199, wherein said at least one bone screw lock in the final position covers at least a portion of at least two of said bone screw receiving holes.

223. The plate of claim 199, wherein at least a portion of said at least one bone screw lock slides from the initial position to the final position.

224. The plate of claim 223, wherein said at least one bone screw lock slides over at least a portion of at least two of said bone screw receiving holes.

225. The plate of claim 199, wherein said at least one bone screw lock comprises at least one of a screw, a rivet, a cap, and a cover.

226. The plate of claim 199, wherein said at least one bone screw lock is adapted to lock to said plate said at least one fastener.

227. The plate of claim 226, wherein said at least one bone screw lock covers at least a portion of at least two of said bone screw receiving holes and at least a portion of said at least one fastener.

228. The plate of claim 226, wherein said at least one bone screw lock slides over at least a portion of at least two bone screws in said bone screw receiving holes and at least a portion of said at least one fastener.

229. The plate of claim 199, wherein at least one end of said plate is configured to cooperatively engage a compression tool for movement of at least one vertebral body.

230. The plate of claim 199, wherein said concave part of said lower surface of said first and second plate segment is configured to conform to the anterior aspect of at least a portion of two cervical vertebral bodies.

231. The plate of claim 199, wherein at least a portion of said lower surface of said first and second plate segment is at least in part concave transverse to the longitudinal axis of the plate.

232. The plate of claim 199, wherein at least a portion of said lower surface of said first and second plate segments is roughened to promote the growth of bone along said lower surface.

233. The plate of claim 199, wherein at least a portion of said lower surface of said first and second plate segments comprises a bone ingrowth surface.

234. The plate of claim 199, wherein at least one of said bone screw receiving holes is configured to form an interference fit with at least a portion of the trailing end of a properly dimensioned bone screw to be received therein.

235. The plate of claim 199, wherein at least one of said bone screw receiving holes is configured to hold a bone screw in fixed relationship to said plate.

236. The plate of claim 199, wherein at least one of said bone screw receiving holes is configured to allow a bone screw to be in a moveable relationship to said plate.

237. The plate of claim 199, wherein at least one of said bone screw receiving holes is configured to allow a bone screw to be in a variable angular relationship to said plate.

238. The plate of claim 199, in combination with an interbody spinal fusion implant.

239. The plate of claim 238, wherein said implant comprises at least in part bone.

240. The plate of claim 238, wherein said implant is an allograft interbody bone graft implant.

241. The plate of claim 238 wherein said implant is an artificial implant.

242. The plate of claim 199, in combination with a fusion promoting substance.

243. The plate of claim 242, wherein said fusion promoting substance is at least in part other than bone.

244. The plate of claim 242, wherein said fusion promoting substance is at least in part bone.

245. The plate of claim 242, wherein said fusion promoting substance is hydroxyapatite.

246. The plate of claim 242, wherein said fusion promoting substance comprises bone morphogenetic protein.

247. The plate of claim 242, wherein said fusion promoting substance comprises genes coding for the production of bone.

248. The plate of claim 199, further comprising bone screws for engaging said plate to the cervical spine, wherein at least a portion of one of said plate, said at least one bone screw lock, and said bone screws is a biore sorbable material.

249. The plate of claim 248, wherein said biore sorbable material is at least in part bone.

250. The plate of claim 199, in combination with a substance for inhibiting scar formation.

251. The plate of claim 199, in combination with an antimicrobial material.

252. The plate of claim 199, wherein said plate is treated with an antimicrobial material.

253. The plate of claim 199, further in combination with at least one spinal fixation implant.

254. The plate of claim 199, further comprising at least one bone screw configured to be in fixed relationship to said plate.

255. The plate of claim 199, further comprising at least one bone screw configured to be in a moveable relationship to said plate.

256. The plate of claim 199, further comprising at least one bone screw configured to be in a variable angular relationship to said plate.

257. The plate of claim 1, wherein at least one of said plate, said fastener, and said bone screw lock is electrified for purposes of stimulating bone growth and contributing to bone fusion.

258. The method of claim 82, further comprising the step of electrifying at least one of the plate, the fastener, the bone screws, and the bone screw lock for purposes of stimulating bone growth and contributing to bone fusion.

259. The plate system of claim 128, wherein at least one of said plate, said fastener, and said bone screw lock is electrified for purposes of stimulating bone growth and contributing to bone fusion.

260. The plate of claim 199, wherein at least one of said plate, said fastener, and said bone screw lock is electrified for purposes of stimulating bone growth and contributing to bone fusion.

* * * * *



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Schär et al.

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(54) TELESCOPIC VERTEBRAL PROSTHESIS

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(73) Assignee: Synthes, Paoli, PA (US)

(*) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

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623/17.15; 606/71; 606/73

(58) Field of Search 623/17.11, 17.13,
623/17.15, 17.16, 16.11, 18.11; 606/61,
73, 74, 75

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(57) ABSTRACT

The invention relates to a device for replacing vertebral bones. The device includes an interior hollow body and an exterior hollow body. These hollow bodies can slide into each other coaxially along a central axis and can be moved in relation to one another in the direction of the central axis. The interior hollow body is provided with a catch mechanism on its outer surface. The exterior hollow body includes a hole or bore extending along the central axis. The exterior hollow body also includes at least one elastic element that projects into the bore at its top end. This reduces the diameter of the bore so that the elastic element latches onto the catch mechanism of the interior hollow body, thereby fixing the length of the device in such a way that it is resistant to compression.

18 Claims, 2 Drawing Sheets

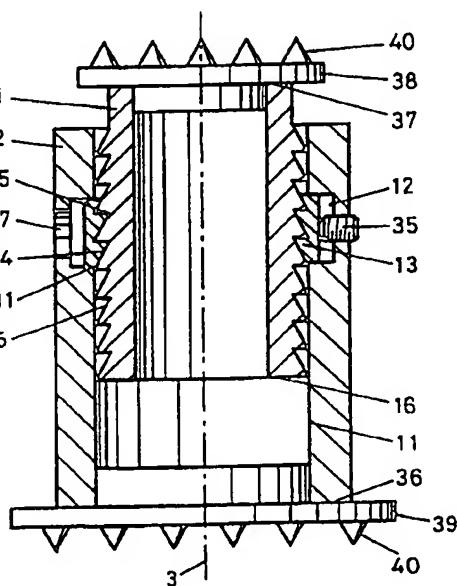


Fig. 2

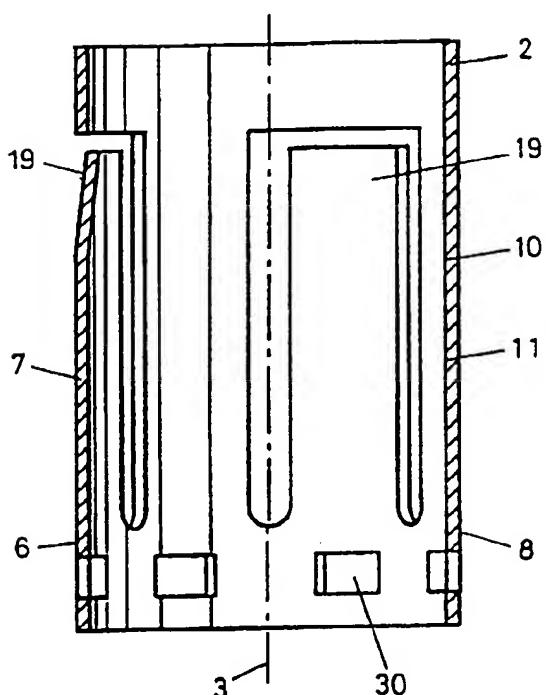


Fig. 1

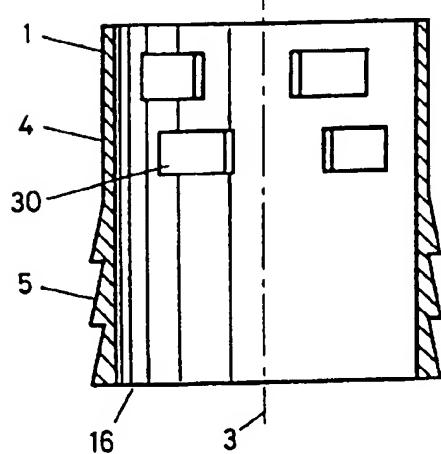


Fig. 3

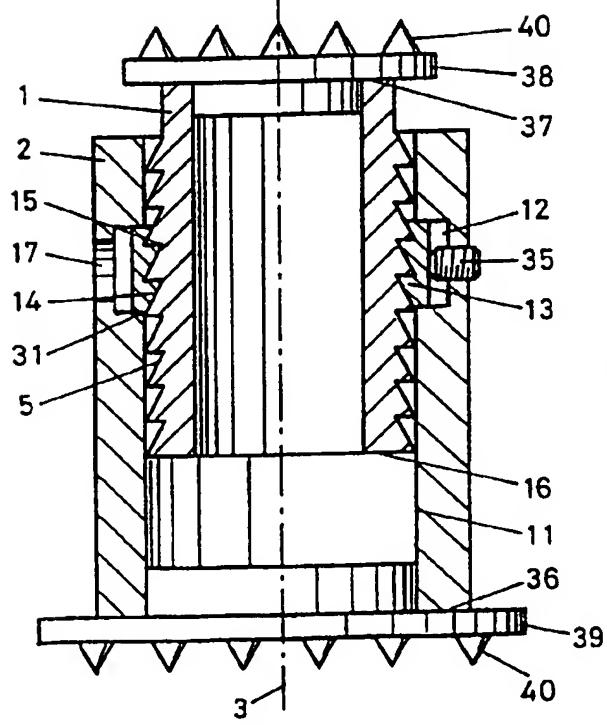


Fig. 4

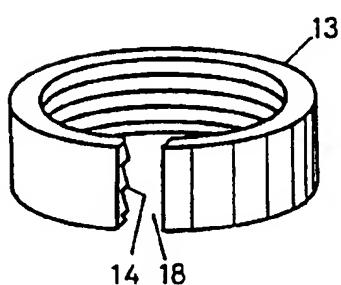


Fig. 5

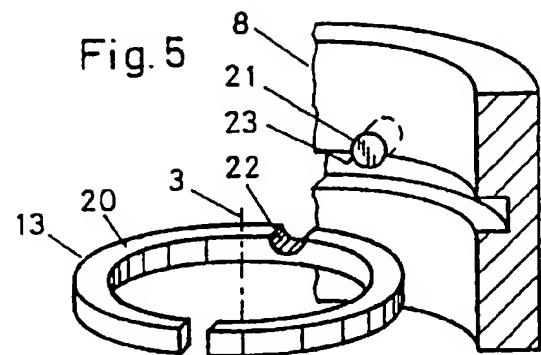


Fig. 6

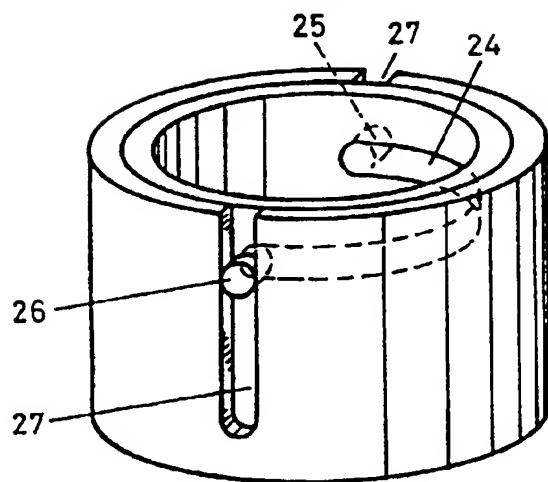
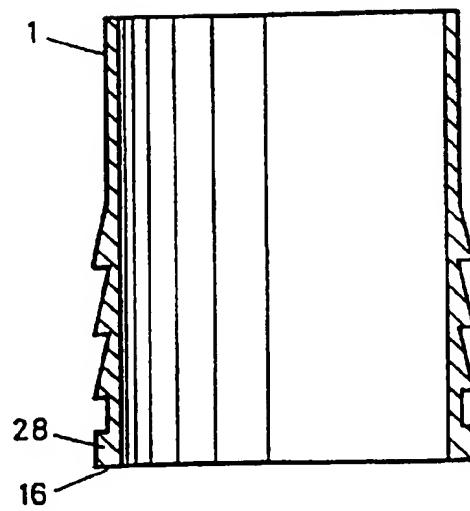


Fig. 7



TELESCOPIC VERTEBRAL PROSTHESIS

FIELD OF THE INVENTION

The present invention concerns a device for replacing vertebrae from the human spinal column.

BACKGROUND OF THE INVENTION

If a vertebra becomes diseased or suffers a defect, it must be removed from the spinal column. Some spacer implants for replacement of missing vertebrae are known from the related art. The implant includes mutually displaceable parts which permit an adjustment of the length of the implant by means of catch mechanisms, among other things, and two special end plates which serve to anchor the implant in the adjacent intact vertebrae. Such vertebral prostheses or implants are known, for example, from Austrian Patent R 24426 RASHEED or German Patent No. 196 04 246 A1 JEANSON.

The disadvantage of these and similar vertebral prostheses is that the two mutually displaceable parts are not closed hollow cylinders and therefore the entire vertebral prosthesis has a low rigidity.

The object of this invention is to obtain the biomechanical and physiological properties of the spinal column despite the removal of a vertebra by using a stable vertebral prosthesis that is adjustable in length. Additionally, ease of handling of the vertebral implant in the course of the surgery is also very important.

This invention achieves this object with a device having the features of claim 1.

SUMMARY OF THE INVENTION

The present invention relates to a vertebral bone prosthetic device having a rigid interior hollow body provided with an outer surface and a catch mechanism thereon. An exterior hollow body has a hole bored therein along a central axis, and is configured and dimensioned to be slidably received by the interior hollow body along the central axis. At least one elastic element projects into the hole thereby reducing the diameter of the bore, and the at least one elastic element engages the catch mechanism for securing the interior hollow body to the exterior hollow body.

In a preferred embodiment of the invention, the vertebral bone prosthetic device has a groove that defines a contact surface, with the groove and the spring having mating conical tapers. At least one hollow body is angled with respect to the central axis, and at least one hollow body has a non-circular cross section.

In another preferred embodiment of the vertebral bone prosthetic device, each catch mechanism includes at least one face defined by a face plane and the at least one face is oriented transverse to a top plane defined by a top end of the interior hollow body. The spring has a pressure-loaded side, with the catch mechanism disposed on the pressure-loaded side.

One embodiment of the device according to this invention includes two telescoping hollow cylinders. The interior hollow cylinder is provided with a catch mechanism on its outer periphery. The exterior hollow cylinder has at least one elastic element which latches into the catch mechanism of the interior hollow cylinder and fixes the length of the device. With the catch mechanism and the latchable elastic element, the device according to this invention can be lengthened and adjusted during surgery.

Another embodiment of the device according to this invention includes two coaxially arranged hollow bodies

that are displaceable along said axis relative to one another, a spring mounted in a groove provided in the exterior hollow body and end plates that serve to anchor the device in the adjacent vertebrae. The interior hollow body is provided with a catch mechanism on its outer surface. On its inner surface, the spring has a catch mechanism which fixes the interior hollow body in the axial direction when it latches into the catch mechanism on said interior hollow body. The spring can also be spread from the outside by using an auxiliary instrument through an opening in the exterior hollow body thereby allowing controlled in situ compression. An embodiment with three hollow bodies that can slide into each other is also possible, with the outer and interior hollow cylindrical surfaces each being designed as in the two-part variant described above.

The advantages achieved through this variant of the invention are to be seen essentially as the fact that a spring with a catch mechanism is built into the device according to this invention to fix the length of the implant. The overall height of the implant can thus be reduced, and when the clearance is small, it can be inserted between adjacent vertebrae, which thus permits the use of this prosthesis even in the vicinity of the cervical vertebrae. By spreading the spring, the vertebral prosthesis according to this invention can be compressed again and removed. In addition, the two hollow cylinders may have relatively thick walls and thus may form a very stable prosthesis.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention and further refinements of this invention are explained in greater detail below on the basis of the partially schematic diagrams of several embodiments, which show:

FIG. 1: a longitudinal section through the interior hollow body 1 of the device according to this invention;

FIG. 2: a longitudinal section through the exterior hollow body 2 of a variant of the device according to this invention;

FIG. 3: a longitudinal section through another embodiment of the device according to this invention;

FIG. 4: a perspective view of the ring-shaped spring 13 according to one embodiment of the device according to this invention;

FIG. 5: a perspective view of the ring-shaped spring 13 with a detail from the exterior hollow body according to one embodiment of the device according to this invention;

FIG. 6: a perspective detail of the two hollow bodies 1, 2 and an elastic strap 24 according to one embodiment of the device according to this invention; and

FIG. 7: another embodiment of the interior hollow body 1 of the device according to this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows the interior hollow body according to an embodiment of the device according to this invention. The catch mechanism 5 on the outer surface is applied to only a part of the length of the interior hollow body. Depending on the design of the device according to this invention, the part of the interior hollow body 1 not provided with the catch mechanism 5 is equipped with radial passages 30.

The exterior hollow cylinder 2 shown in FIG. 2 corresponds to an embodiment of the device according to this invention having multiple tongues 19 as elastic element 7; these tongues are cut out of the wall 6 of the exterior hollow cylinder 2 and bent toward the central axis 3. Depending on

the embodiment of the device according to this invention, the exterior hollow cylinder 2 is equipped with radial passages 30.

The variant of the device according to the present invention shown in FIG. 3 illustrates the exterior hollow body 2, which is provided with on the inside, surface 11 coaxially with central axis 3, a cylindrical bore 10, a cylindrical groove 12 and an opening 17 extending from this groove 12 to the outer surface of the exterior hollow body 2. The interior hollow body 1, which is provided with a catch mechanism 5 on its outer surface, 4 is arranged so it can slide in the exterior hollow body 2 and can be displaced relative to it along the central axis 3. A spring 13, which is provided on the inside with a catch mechanism 14 with a form fit with the catch mechanism 5 of interior hollow body 1, is inserted into the groove 12. If the spring 13 is spread with an auxiliary means which can be inserted into the gap 18 of spring 13 through the opening 17 in the exterior hollow element 2, the interior hollow body 1 can be displaced in both directions relative to the exterior.

Another variant of the device according to this invention as shown in FIG. 3 is equipped with a locking screw 35 passing radially through the exterior hollow body 2 in the area of groove 12 to block the two hollow bodies 1, 2 in the direction of the central axis 3.

FIG. 3 also shows variants of the device according to the present invention; they are equipped with end plates 38, 39, which may have mandrels 40 on the bone side, on both free ends 36, 37 of the hollow bodies 1, 2.

The ring-shaped spring 13 of the device according to the present invention as illustrated in FIG. 3 is shown in FIG. 4. The spring 13 is opened at the periphery through a gap 18. A catch mechanism 14 which can be latched into the catch mechanism 5 on the outer periphery of interior hollow body 1 is attached to the inner surface of the ring-shaped spring 13.

FIG. 5 shows another embodiment of the version of the device according to this invention as shown in FIG. 3. A pin 21 is inserted into an opening 23 passing radially through the exterior hollow body 2, engaging in a notch 22 on the top end face 20 of the spring 13, thus preventing the spring 13 from rotating about the central axis 3.

FIG. 6 shows another embodiment of the device according to the present invention. An elastic strap 24 with free ends 25, 26 that are bent outward and can be latched into longitudinal slits 27 on the exterior hollow body 2 secures the two hollow bodies 1, 2 to prevent rotation.

In another embodiment shown in FIG. 7 of the version of the device according to the present invention shown in FIG. 3, the interior hollow body 1 is provided with a shoulder 28 on its lower end 16, the outside diameter of said shoulder being greater than the inside diameter of the unextended spring 13. The shoulder 28 on the bottom end 16 prevents the interior hollow body 1 from sliding upward along spring 13, thereby slipping out of the exterior hollow body 2.

What is claimed is:

1. A vertebral bone prosthetic device comprising:
a rigid interior hollow body provided with an outer surface and a catch mechanism thereon;
an exterior hollow body with a hole therein extending along a central axis, with the exterior hollow body being configured and dimensioned to be slidably received by the interior hollow body along the central axis; and
an at least one elastic element projecting into the hole to engage the catch mechanism for securing the interior hollow body to the exterior hollow body.

2. The vertebral bone prosthetic device of claim 1 wherein at least one hollow body is a hollow cylinder.

3. The vertebral bone prosthetic device of claim 1 wherein the at least one elastic element is a tongue formed in a wall of the exterior hollow body.

4. The vertebral bone prosthetic device of claim 1, wherein the exterior hollow body includes longitudinal slits and the device further comprises an elastic strap having bent free ends latchable in the longitudinal slits to prevent twisting of the exterior and interior hollow bodies.

5. The vertebral bone prosthetic device of claim 1 further comprising a ring-shaped spring having inside periphery with a spring catch mechanism disposed thereon and a gap, wherein the spring is mounted in a groove formed in the inside surface of the exterior hollow body and wherein the spring catch mechanism engages the catch mechanism of the interior hollow body.

6. The vertebral bone prosthetic device of claim 5 further comprising auxiliary means insertable through a hole in the exterior hollow body, wherein the auxiliary means engages the gap of the spring thereby unlatching the spring catch mechanism from the catch mechanism of the interior hollow body.

7. The vertebral bone prosthetic device of claim 5, wherein the spring includes an end face and a notch thereon.

8. The vertebral bone prosthetic device of claim 7 further comprising a pin which is insertable through a hole in the exterior hollow body for engaging the notch in the spring to secure the spring and prevent its rotation about the central axis.

9. The vertebral bone prosthetic device of claim 5, wherein the interior hollow body is provided with a shoulder on its lower end, the outside diameter of the shoulder being greater than the inside diameter of the spring, thereby preventing relative sliding movement between the interior hollow body and the exterior hollow body.

10. The vertebral bone prosthetic device of claim 5, wherein the groove defines a contact surface, the groove and the spring having mating conical tapers.

11. The vertebral bone prosthetic device of claim 5, wherein each catch mechanism includes at least one face defined by a face plane and is oriented transverse to a top plane defined by a top end of the interior hollow body.

12. The vertebral bone prosthetic device of claim 11, wherein the spring has a pressure-loaded side, and the catch mechanism is disposed on the pressure-loaded side.

13. The vertebral bone prosthetic device of claim 1, wherein each hollow body has at least one through hole formed in a wall of the hollow body.

14. The vertebral bone prosthetic device of claim 1, wherein at least one hollow body is angled with respect to the central axis.

15. The vertebral bone prosthetic device of claim 1, wherein at least one hollow body has a non-circular cross section.

16. The vertebral bone prosthetic device of claim 1, wherein end plates are mounted on opposing ends of the hollow bodies.

17. The vertebral bone prosthetic device of claim 16, wherein each end plate has a bone side with mandrels mounted thereon.

18. The vertebral bone prosthetic device of claim 1, further comprising a locking screw which is screwed into the exterior hollow body.

* * * * *



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United States Patent [19]
Seldin

[11] Patent Number: 5,672,177
[45] Date of Patent: Sep. 30, 1997

[54] IMPLANTABLE BONE DISTRACTION DEVICE

[75] Inventor: Edward B. Seldin, Cambridge, Mass.

[73] Assignee: The General Hospital Corporation,
Boston, Mass.

[21] Appl. No.: 594,157

[22] Filed: Jan. 31, 1996

[51] Int. Cl⁶ A61B 17/58

[52] U.S. Cl. 606/71; 606/105

[58] Field of Search 606/53, 54, 55,
606/57, 58, 69, 70, 71, 86, 87, 105, 74,
151

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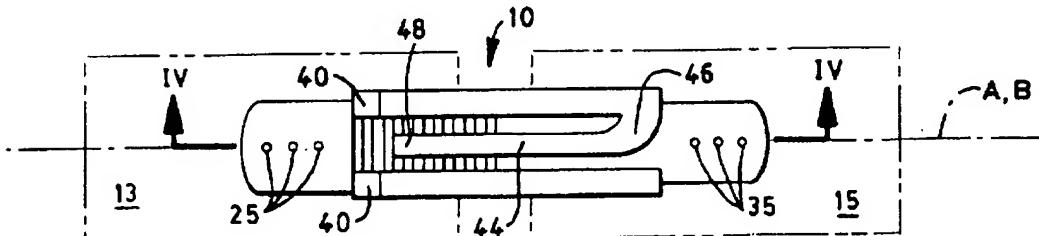
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Attorney, Agent, or Firm—Lappin & Kusner LLP

[57] ABSTRACT

An implantable bone distraction device for inducing controlled lengthening of at an osteotomy site. The device has two elongated plates which are operatively positioned to be substantially parallel and to overlap partially. Each of the plates includes a portion adapted for affixing the plates to respective bone segments. The first plate includes a plurality of parallel sawtooth ridges extending transverse from the long axis of the plate. The second plate includes at least one resilient pawl and at least one resilient ratchet arm. The pawl and arm are engageable with the ridges on the first plate. The ratchet arm responds to application of force on it by engaging with one of the ridges on the first plate and pushing the first plate away from the second plate in the direction of their common axes. The first bone segment is thus moved away from the second bone segment in the direction of the common axes of the plates in a controlled fashion. Backward movement of the first plate toward the second plate is prevented by the abutting engagement of the pawl with one of the ridges on the first plate.

8 Claims, 4 Drawing Sheets



Doesn't preclude moving away
from pawl

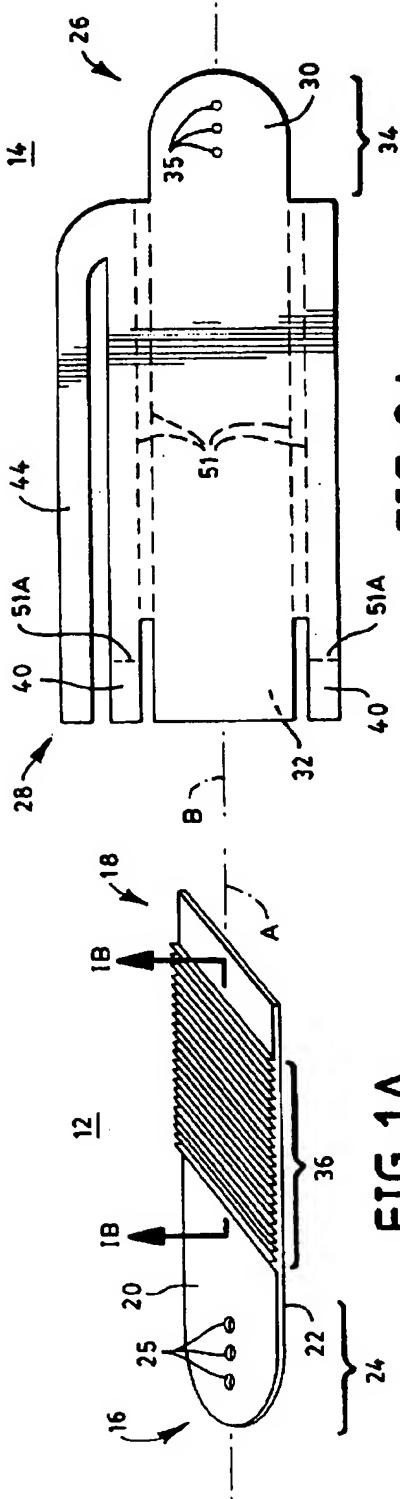


FIG. 1A

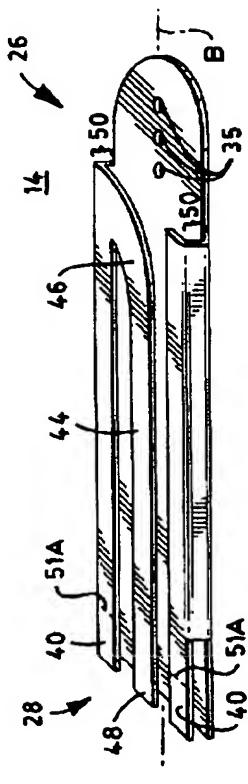


FIG. 2A

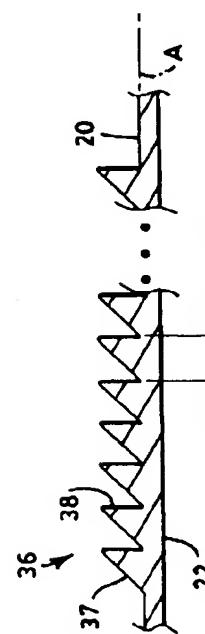


FIG. 1B

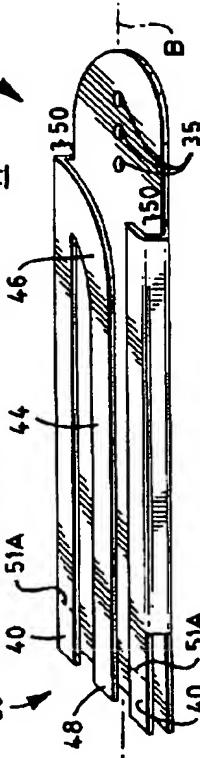


FIG. 2B

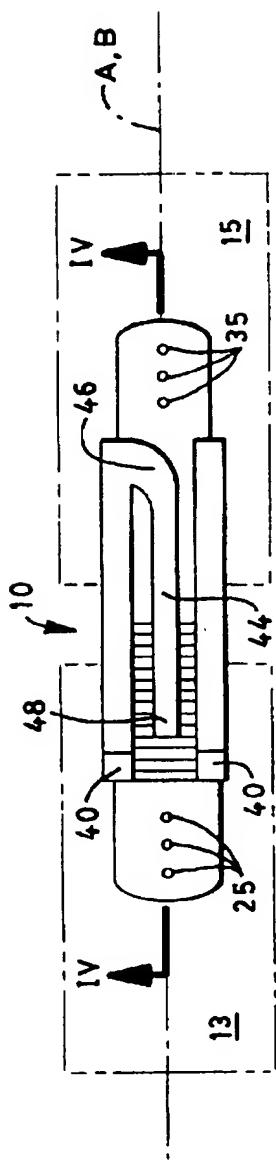


FIG. 3

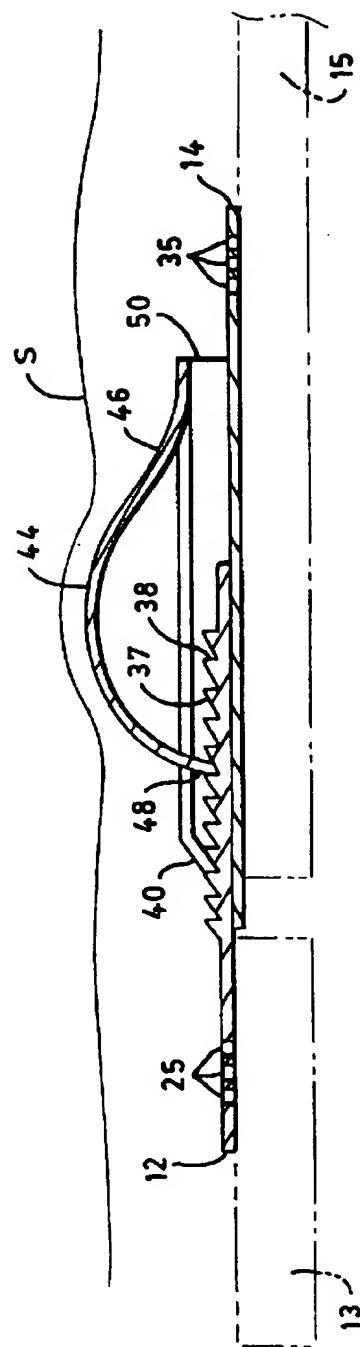


FIG. 4

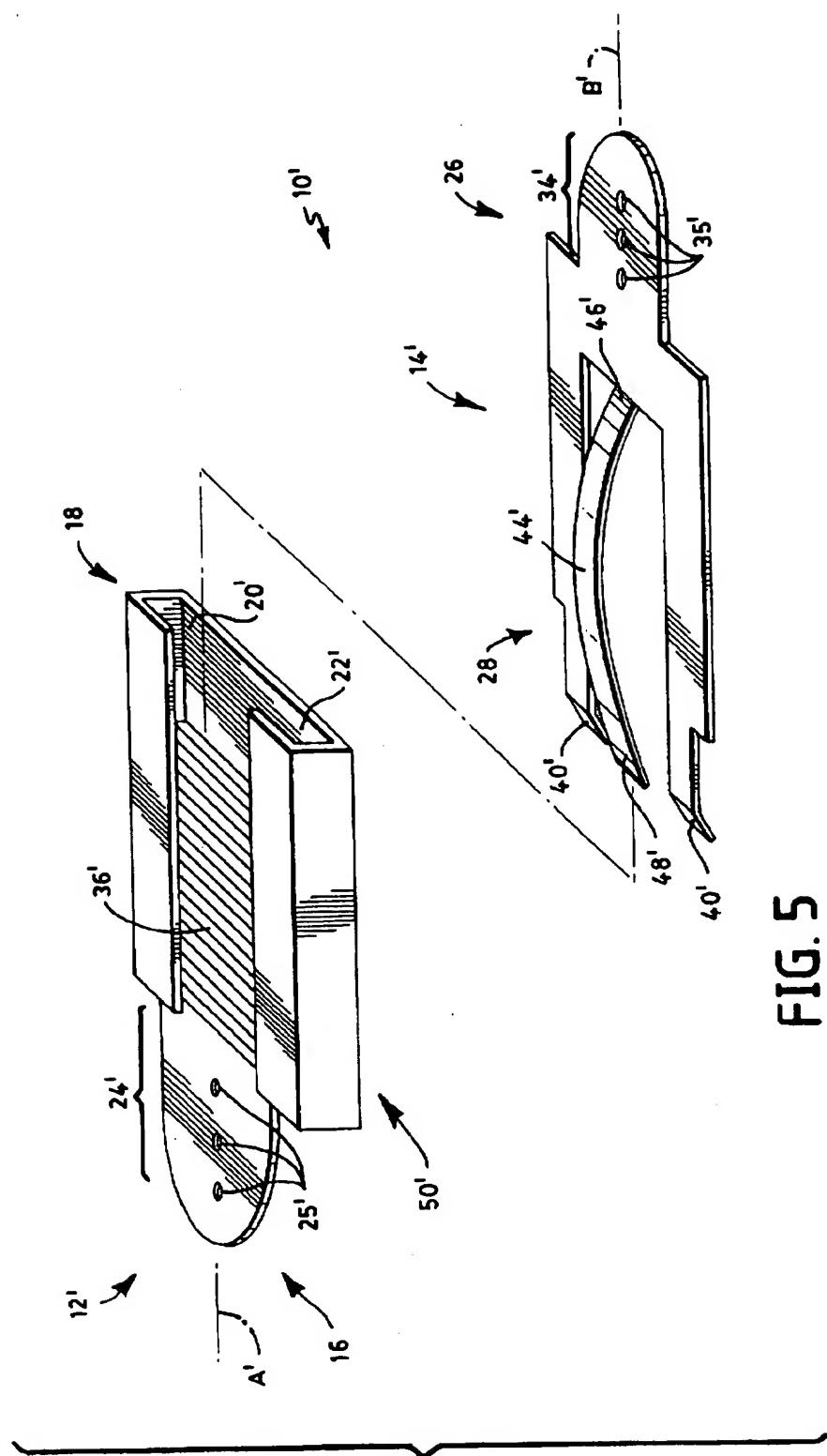


FIG. 5

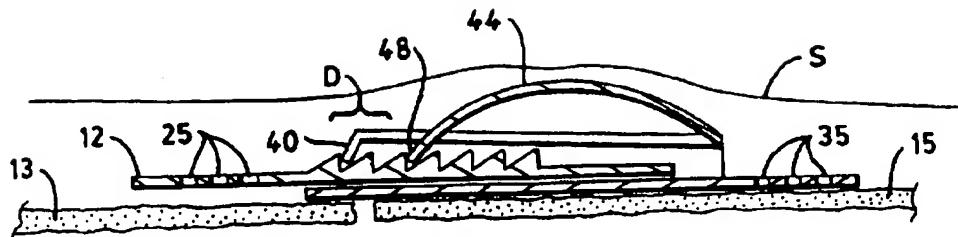


FIG. 6A

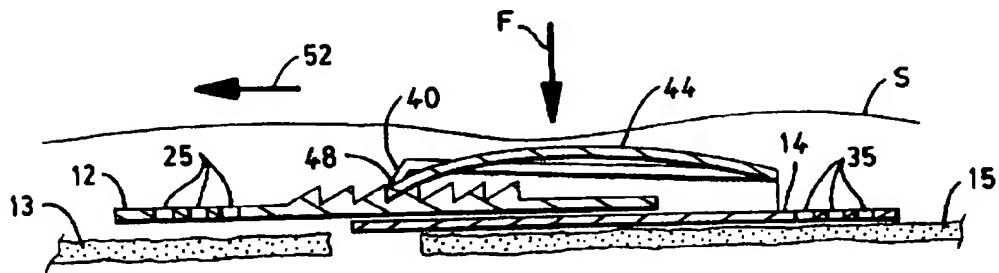


FIG. 6B

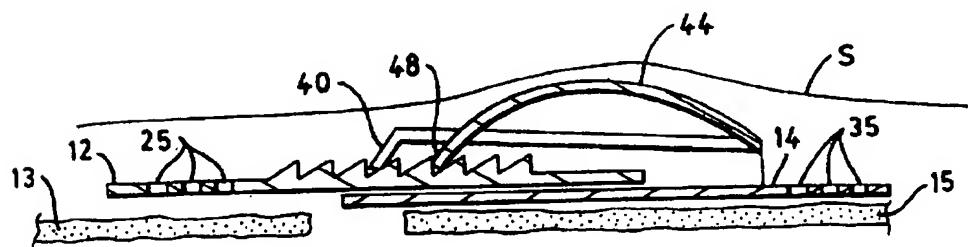


FIG. 6C

IMPLANTABLE BONE DISTRACTION DEVICE

FIELD OF THE INVENTION

The present invention relates to surgical devices used in distraction osteosynthesis to induce and control the lengthening of bones at the site of an osteotomy. More particularly, the invention relates to implantable bone distraction devices.

BACKGROUND OF THE INVENTION

Distraction osteosynthesis is a surgical procedure in which the natural reparative and regenerative properties of bone are employed to induce controlled lengthening of bone sections at the site of an osteotomy. The procedure is typically employed in corrective jaw and facial surgery, as well as in other types of reconstructive surgery.

Bone distraction devices are generally affixed to separate sections of bone on either side of an osteotomy with transcutaneous pins. The device may include other transcutaneous projections which are adapted for receiving external forces for adjusting the device from outside of the patient.

Because portions of the device extend through the patient's skin, the patient experiences great discomfort. Further, the pins are unsightly and cause unavoidable, sometimes severe, scarring, especially in areas of sensitive skin on the face and neck. Such consequences have been considered acceptable only because of the severity of the underlying conditions and the necessity for radical treatment.

A typical bone distraction device and method are disclosed in U.S. Pat. No. 5,364,596 to Robinson et al. The disclosed device comprises a pair of blocks, one defining a drive chamber and the other defining a threaded bore which receives a threaded, rotatable drive rod. The blocks have a relatively low profile to facilitate their subcutaneous implantation and attachment to bone sections on either side of an osteotomy. A percutaneous port projects outwardly from one of the blocks to permit adjustment of the device. A separate adjustment tool cooperates with a drive rod actuator to rotate the drive rod and adjust the spacing between the blocks to control the distraction process.

The Robinson et al. device is not totally implantable within the patient. The percutaneous port is unsightly and uncomfortable for the patient, and scarring at the site of the percutaneous port cannot be avoided.

It would be an advancement in the art to provide a bone distraction device which is wholly implantable within a patient and which can be adjusted as needed without reopening the osteotomy site or otherwise requiring the use of an invasive device or procedure.

SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided an implantable device for distracting first and second bone segments. The device comprises an elongated first plate which extends along a first axis between first and second ends, and an elongated second plate which extends along a second axis between first and second ends. Each of the plates has an upper surface and a lower surface. The first plate has a portion near its first end which is adapted for affixing the first plate to the first bone segment so that the lower surface of the first plate is adjacent to the first bone segment. The second plate has a portion near its second end which is also adapted for affixing the second plate to the second bone segment so that the lower surface of the second plate is adjacent to the second bone segment.

The device further includes an assembly for positioning the first and second plates so that they are parallel and overlap to the extent that at least the portion of the first plate that includes the second end is adjacent to at least the portion of the second plate that includes the first end. As positioned, the first and second axes of the respective plates are substantially parallel. The first plate is movable with respect to the second plate in the direction of the first and second axes.

The upper surface of the first plate includes a plurality of parallel saw-tooth ridges which extend transverse to the first axis. Each of the ridges includes a drive surface which extends from, and is substantially perpendicular to, the upper surface of the first plate. The drive surfaces of the ridges face the second end of the first plate.

The second plate includes at least one resilient pawl which extends from the first end of the second plate. The pawl is biased toward, and is engageable with, the ridges on the first plate. The second plate further includes at least one resilient, elongated, arcuate arm which has a proximal end and a distal end. The proximal end extends from the first end of the second plate, with its distal end extending toward and being engageable with the ridges on the first plate.

In one embodiment, the positioning assembly comprises at least one extension from the second plate, the extension forming a guide that is adapted for partially enclosing at least a portion of the first plate. In another embodiment, the positioning assembly comprises at least one extension from the first plate which forms a guide adapted for partially enclosing at least a portion of the second plate.

These and other features of the invention will be more fully appreciated with reference to the following detailed description which is to be read in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further described by the following description and figures, in which:

FIG. 1A is a plan view of the first plate of the device according to one embodiment of the invention;

FIG. 1B is a section view of the first plate shown in FIG. 1, taken along section 1B—1B;

FIG. 2A & 2B are a plan view of the second plate of the device according to the embodiment shown in FIG. 1;

FIG. 3 is a plan view of the embodiment of the device of FIGS. 1 and 2, in which the first and second plates are operatively engaged;

FIG. 4 is a sectional view of the device shown in FIG. 3, taken along section lines IV—IV;

FIG. 5 is an exploded perspective view of another embodiment of the invention;

FIGS. 6A—6C are sequential schematic representations of the device of FIG. 1 in use in distracting two bone segments.

Like elements in the respective FIGURES have the same reference numbers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The bone distraction device of the present invention is wholly implantable within a patient and can be adjusted from outside the patient without reopening the osteotomy site and without requiring transcutaneous projections. The device includes two plates, each of which is engaged to a bone segment and which engage with one another. The device is configured so that the engaged plates may be

operated in a ratcheting manner in response to the extracorporeal application of forces thereby effecting controlled lengthening of the device and thus inducing controlled lengthening of the bone segments to which the plates are attached.

A preferred form of the invention is shown as device 10 in FIGS. 1A-4. FIG. 4 shows the device 10 subcutaneously implanted beneath the skin S of a patient. The device 10 comprises a first elongated plate 12, as shown in FIG. 1A, and a second elongated plate 14, as shown in FIGS. 2A and 2B. The first elongated plate 12 extends along a first axis A between a first end 16 and a second end 18. The plate 12 has an upper surface 20 and a lower surface 22, and a portion 24 near the first end 16 of the plate adapted for affixing the plate 12 to a first bone segment 13 (shown in FIGS. 3 and 4) so that the lower surface 22 of the plate 12 is adjacent to the first bone segment. The upper surface 20 of the first plate 12 includes a plurality of parallel saw-tooth ridges 36, shown in detail in FIG. 1B. The ridges 36 extend transverse to the axis A of the first plate. Each ridge includes a sloped surface 37 and a drive surface 38, as shown. The drive surface 38 extends from, and is substantially perpendicular to, the upper surface 20 of the plate, and the sloped surface 37 is inclined with respect to the upper surface 20. The drive surfaces 38 of the ridges face the second end 18 of the first plate, and the sloped surfaces 37 face the first end 16. FIGS. 2A and 2B show a second plate 14 that is adapted for use with plate 12. In the illustrated embodiment, plate 12 is stamped from a sheet material to the form shown in FIG. 2A, and then folded along fold lines 51 to be in the form shown in FIG. 2B.

As shown in FIG. 2, the second plate 14 extends along a second axis B between a first end 26 and a second end 28. The second plate also has an upper surface 30 and a lower surface 32, and a portion 34 near the first end 26 adapted for affixing the second plate to a second bone segment 15 (shown in FIGS. 3 and 4) so that the lower surface 32 of the second plate 14 is adjacent to the second bone segment.

The second plate 14 includes two resilient pawls 40 which extend from the second end 28 of the second plate 14 and are bent along fold lines 51A (as shown in FIG. 3) toward upper surface 30. Although the illustrated embodiment includes two pawls, other embodiments may have a different number of pawls. Prior to implantation, the pawls 40 are bent along fold lines 51A toward upper surface 30, as shown in FIG. 3. The second plate 14 further includes at least one resilient, elongated ratchet arm 44. The proximal end 46 of the arm 44 joins the arm to the first end 26 of the plate 14, and the distal end 48 of the arm extends toward the distal end 28. When plates 12 and 14 are assembled to be a two-element device, the distal end 48 of arm 44 extends over the first plate 12 and towards the ridges 36, as will be more fully explained below. In the illustrated embodiment, as shown in FIGS. 2A and 2B, the arm 44 is planar, but before implantation, it is imparted with a curvature, for example, to have the general shape shown in FIG. 4, so that end 48 will engage one of the ridges 36 when device 10 is assembled.

The portions 24, 34 of the respective plates 12, 14 which are adapted for affixing the plates to bone segments 13, 15 include sets of holes 25, 35 in the respective plates which are adapted for receiving threaded bone screws, pins or fasteners (not shown), or other securing devices suitable for use in anchoring the plates to bone.

The device further includes an assembly 50 for supporting the plates together so that their principal planes are substantially parallel and their respective axes A and B are substan-

tially parallel, as shown in FIG. 3, and plate 12 is slidably positioned (in the direction of axes A, B) with respect to plate 14. The positioning assembly 50 restricts movement of the first plate 12 to movement only in the direction of the axes A and B. In one embodiment, the positioning assembly 50 comprises at least one extension from the second plate which is adapted to form a guide or channel for partially enclosing at least a portion of the first plate 12. In another embodiment, the positioning assembly 50 comprises at least one extension from the first plate which is adapted to form a guide or channel for partially enclosing at least a portion of the second plate.

In the positioning assembly 50, the plates 12, 14 overlap so that at least the portion of the first plate 12 that includes the second end 18 of that plate is adjacent to at least the portion of the second plate 14 that includes the first end 26 of that plate.

In the embodiment of the invention illustrated in FIGS. 1A-4, the second plate 14 is made of a unitary construction. The positioning assembly 50 in this embodiment comprises a pair of extensions from a central portion of the second plate 14. The extensions are formed along fold lines 51 into a guide channel for partially enclosing the first plate 12, as shown in FIGS. 2B and 3.

An alternative form of the invention is shown as device 10' in FIG. 5. The device includes two elongated plates 12' and 14' extending along respective axes A', B'. The first plate 12' includes an upper surface 20' and a lower surface 22' and a portion 24' near the first end adapted for affixing the first plate to a first bone segment (not shown) so that the lower surface 22' is adjacent to the first bone segment. The second plate 14' also includes an upper surface 30' and a lower surface 32' and a portion 34' near the first end which is adapted for affixing the second plate to a second bone segment (not shown) so that the lower surface 32' is adjacent thereto.

The upper surface 20' of the first plate 12' includes a plurality of sawtooth ridges 36' extending transverse to the axis A', as in the embodiment of FIGS. 1A-4. Each ridge includes a sloped surface 37' which is inclined relative to the upper surface 20', and a drive surface 38' which is substantially perpendicular to the upper surface 20' of the first plate. As in the embodiment of FIGS. 1A-4, the drive surfaces 38' face the second end of the first plate and the sloped surfaces 37' face the first end.

Portions 24', 34' of the respective plates 12', 14' are adapted with holes 25', 35' for affixing the respective plates to respective bone segments 13, 15 (not shown) with threaded bone screws, pins, fasteners (not shown), or other suitable securing devices, as in the embodiment of FIGS. 1A-4.

In the embodiment of FIG. 5, the first plate 12' includes a positioning assembly 50', which comprises a pair of extensions from either side of a central portion of the first plate. As with the embodiment of FIGS. 1A-4, the extensions can be formed into a guide channel for receiving and partially enclosing at least a portion of the second plate 14', as explained more fully below.

The second plate 14' includes at least one, and preferably a pair of, resilient pawls 40' which extend from the end of 28' the second plate, as in the embodiment of FIGS. 1A-4. The second plate further includes an elongated, resilient, ratchet arm 44' extending from the first end 26' of the second plate. The lateral edges of plate 14' are adapted to fit within the guide channels formed from the extensions of the first plate 12', and, when assembled, the ratchet arm 44' engages

with the ridges 36 between the channels so formed, as shown in FIG. 5.

The plates 12, 12', 14, 14' are preferably made of a biocompatible material, such as, for example, titanium or vitallium, which is suitable for implantation in a patient. Alternatively, the plates can be constructed of a biodegradable material which is designed to break down over time in the body and be absorbed into the surrounding tissues and/or excreted as waste.

In use, the device 10 is first implanted under the patient's skin S over the two bone segments 13, 15 which are to be distracted by a predetermined distance. The plates 12, 14 of the device are then affixed to the respective bone segments 13, 15 with bone screws or the like at holes 25, 35. The osteotomy site is then closed.

To distract the bone segments 13, 15, a succession of forces is applied through the skin to the ratchet arm 44 of the device. In response to these forces, the device 10 operates with a ratcheting action that permits the controlled lengthening of the device in the direction of the first and second axes A, B and thus of the bone segments 13, 15 affixed to the respective plates 12, 14.

FIGS. 6A-6C schematically illustrate the device 10 as implanted under the skin S of a patient and in operation. The first plate 12 includes eight transverse ridges 36 and spaced apart by a distance D, equal to the pitch of the ridges on the plate. A ridge which is forward (i.e., to the left in FIGS. 6A-6C) of the ratchet arm 44 and pawl 40 is designated as a "leading" ridge, and a ridge which is rearward (i.e., to the right in the FIGURE) of the ratchet arm 44 and pawl 40 is designated as a "trailing" ridge. A ridge which is engaged by the resilient pawl is designated as the "engaging" ridge. As shown, the second plate 14 includes one resilient pawl 40 and a ratchet arm 44 extending from the first end of the second plate. The ratchet arm 44 extends over the first and second plates 12, 14 to a point near the ridges on the first plate. The arm 44 includes a distal end 48 which is adapted for engagement with the ridges on the first plate. The resilient pawl 40 at its distal end is also adapted for engagement with the ridges on the first plate. The plates 12, 14 are positioned so that their axes A, B are substantially parallel and so that the plates overlap to the extent that at least the portion of the first plate that includes the second end is adjacent to the portion of the second plate that includes the first end.

Initially, as shown in FIG. 6A, the plates are stationary with respect to each other, and the distal finger end of the resilient pawl 40 abuts against a drive surface of the leftmost engaging ridge to prevent the first plate 12 from moving toward the second plate 14. In the absence of any appreciable downward force on the ratchet arm 44, that arm is in a relaxed state with its distal end 48 located generally between the third and fourth engaging ridges, as shown in FIG. 6A.

In FIG. 6B, a downward force F is applied through the patient's skin S to the ratchet arm 44. That force depresses the arm and causes it to elongate in the direction of its free end 48, i.e., toward the first end of the first plate in the direction of arrow 52. The distal end 48 of the arm 44 abuts against a drive surface 38 of the third ridge on the first plate, and the force thus applied to the arm 44 pushes the first plate 12 away from the second plate 14 along the axes A and B. In the illustrated example, the force establishes relative motion between plates 12 and 14 in the amount of 2D (i.e., two ridges). The distal end of the resilient pawl 40 overrides the sloped surface 37 of the second and third ridge as the first

plate 12 moves away from the second plate 14. The device 10 is thereby lengthened by distance 2D, and the bone segments 13, 15 affixed to the respective plates 12, 14 are distracted by distance 2D along the common axes A, B. After that motion of plate 12 relative to plate 14 is established, the pawl 40 is biased against the drive surface of the third ridge, preventing motion in a direction opposite to arrow 52.

In FIG. 6C, the plates 12, 14 are stationary relative to each other as in FIG. 6A. The absence of force on the arm 44 relaxes the arm to its rest state, and the distal tip 48 of the arm 44 rests between the fifth and sixth ridges. The distal finger end of the resilient pawl 40 engages with drive surface 38 of a now-engaging ridge and thus prevents backward movement of the first plate 12 toward the second plate 14.

Subsequent applications of force on the arm 44 advance the first plate 12 away from the second plate 14 along the common axes A, B in a ratcheting motion along the ridges of the first plate, as previously described. Backward movement of the first plate 12 toward the second plate 14, and thus of the first bone segment 13 toward the second bone segment 15, is prevented by the abutting engagement of the pawls 40 with the driving surface 38 of the ridge with which the distal end 48 of the arm 44 was previously engaged.

Thus, the device can be actuated to induce bone distraction by, for example, digital application of force on the skin immediately overlying the device. Such action depresses the arm 44 and moves the first plate 12 away from the second plate 14 as previously described. Alternatively, the device can be activated magnetically by energizing an electric circuit (not shown) associated with the device and transmitting one or more electric pulses to an electromagnetic relay to depress the arm and effect movement of the first plate relative to the second plate. Other means for directly or remotely activating the device by application of pressure on the arm can also be used.

The device can be made in a wide variety of shapes and sizes to accommodate any type of reconstructive surgery or bone distraction requirements. For example, the plates can extend along axes which are curvilinear in order to permit distraction of bone segments attached thereto in a curvilinear direction around predetermined centers of rotation. The plates can alternatively be constructed to incorporate compound shapes to induce various combinations of linear and curved bone growth. Further, the plates can be designed to include preselected angles, or they can be adjusted to produce a desired growth angle, to induce bone distraction according to a predetermined geometry. In a preferred embodiment, the plates of the device can be fabricated from sheet metal stock which can be easily folded to form the enclosing portion of the device; however, other fabrication modes, such as, for example, fabrication by casting or machining or other known methods, are considered to fall within the scope of the invention.

The bone distraction device of the present invention is highly advantageous for use in bone distraction surgery, because it is wholly implantable within the patient and can be easily adjusted from outside the patient. Scarring and the potential for infection due to the presence of unsightly and uncomfortable transcutaneous pins are eliminated. Bone distraction is easily effected by mere application of force on the ratchet arm of the device through the patient's skin, without the need for reopening the osteotomy site.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the

scope of the invention being indicated by the appended claims rather than by the foregoing description. All changes that come within the meaning and range of the equivalency of the claims are therefore intended to be embraced therein.

I claim:

1. An implantable device for distracting first and second bone segments, comprising:

A. an elongated first plate extending along a first axis between first and second ends thereof, said first plate having an upper surface and a lower surface, and having means near said first end for affixing said first plate to said first bone segment whereby said lower surface of said first plate is adjacent to said first bone segment;

B. an elongated second plate extending along a second axis between first and second ends thereof, said second plate having an upper surface and a lower surface, and having means near said first end for affixing said second plate to said second bone segment whereby said lower surface of said second plate is adjacent to said second bone segment;

C. and means for positioning said first and second plates to be slidably engaged, with at least the portion of said first plate including said second end being adjacent to at least the portion of said second plate including said first end, whereby said first and second axes are substantially parallel, and whereby said first plate is movable with respect to said second plate in the direction of said first and second axes;

wherein said upper surface of said first plate includes a plurality of parallel saw-tooth ridges extending transverse to said first axis, each of said ridges including a drive surface, said drive surface extending from, and being substantially perpendicular to, said upper surface of said first plate and facing said second end of said first plate,

wherein said second plate comprises at least one resilient pawl extending from said first end of said second plate, said pawl being biased toward and engaging with one of said ridges, and

5 wherein said second plate further comprises at least one resilient elongated ratchet arm having a proximal end extending from said first end of said second plate and a distal end extending toward and engaging with one of said ridges.

10 2. A device according to claim 1, wherein said means for affixing said plates to said bone segments comprises a plurality of bone screws for threading into each of said bone segments through a plurality of holes in each of said plates.

15 3. A device according to claim 1, wherein said arm and said pawl are adapted for engagement with a drive surface on one of said ridges on said first plate.

4. A device according to claim 3, wherein application of force on said arm causes said arm to engage with said drive surface, thereby moving said first plate away from said second plate along said axes, and wherein release of force on said arm causes said arm to disengage from said drive surface and causes said pawl to engage with said drive surface, thereby preventing movement of said first plate toward said second plate.

5. A device according to claim 1, wherein said plates are made of a biocompatible material.

25 6. A device according to claim 5, wherein said plates are made of a biodegradable material.

7. A device according to claim 1, wherein said positioning means comprises at least one extension from said second plate, wherein said extension forms a guide for partially enclosing at least a portion of said first plate.

30 8. A device according to claim 1, wherein said positioning means comprises at least one extension from said first plate, wherein said extension forms a guide for partially enclosing at least a portion of said second plate.

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